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Time and Skill Requirements for Handling Agricultural Products at Fixed Work Places

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TIME AND SKILL REQUIREMENTS FOR HANDLING AGRICULTURAL PRODUCTS AT FIXED WORK PLACES

Jack C. Thompson
Director of Cornell Methods Laboratory

Paul V. Weaver
Research Associate

Max E. Brunk
Professor of Marketing

Cornell University

PREFACE

The study on which this report is based was made by the New York State College of Agriculture at Cornell University under a contract with the United States Department of Agriculture. The contract was administered by William H. Elliott, head, Handling and Facilities Research Section, AMS. The manuscript for this publication was prepared by the contractor October 15, 1954.

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CHAPTER I

INTRODUCTION

The original theory on which this project is based was published by the project leaders in 1951. 1/ The objective of this project as stated in the Work Project description is:

> To determine the degrees of skill and effort involved in individual basic motions, to classify them accordingly, and to establish standard time values for basic motions involved in agricultural marketing processes.

The ultimate purpose of such data is the selection of the most effective work method from among alternatives.

Work methods must be selected and there are several ways, other than the use of predetermined time values, for selecting them. Unfortunately the least effective methods often predominate in actual practice.

The usual procedure is to tackle the job and get it done the best way one can. A period of training and instruction would certainly improve the starting efficiency. But even so, getting the job done is infinitely better than not getting it done. A few quick corrections are usually made in the method and then the worker continues from that point on with no further thought aimed at correcting or improving the method. This might be called "hit or miss technique."

Another approach is to do the work the "customary" way. This procedure might be good or bad depending on whose custom is adopted. Many obsolete methods are kept alive for generation after generation by this procedure. Of course, if the individual whose method is copied happens to have a very good method, the results may be excellent. The accepted procedure is to look around for a successful firm, then assume that because the overall firm is successful, their method of doing each task must be excellent, too.

A third procedure is to employ the techniques of work measurement. One of these techniques is orthodox time study. The other is the use of predetermined time values, establishment of which is the objective of this project.

1/ Brunk, Max E. and Thompson, Jack C. Maximizing Worker Productivity Through Evaluation of Its Components--A Hypothesis. Jour. Farm Econ., vol. XXXIII, No. 3, Aug. 1951.

Predetermined Time Values Versus Orthodox Time Study

Orthodox time study is a combination of scientific measurement and personal judgment. The element of personal judgment is rather large. The observer, with a stopwatch, records the actual time the worker takes to perform the elements which constitute his task. At the same time he rates the worker's speed of activity. This rating is usually expressed in percent and is based on the observer's mental concept of a normal rate of activity for that particular type of work. If the observer believes that the worker is working at a pace which is 25 percent faster than normal, his rating will be 125. If he believes the worker is working 20 percent slower than normal, his rating would be 80 percent. Normal is then computed by multiplying the rating by the actual time. If the actual time were .5 of a minute and the rating were 120 percent, then normal would be 1.20 X .5 = .6 of a minute. The weak spot in this procedure is that the rater never has a check on the accuracy of his rating. He has no guide for correcting his errors of judgment. Consequently, he may be getting progressively worse with experience.

A variation of this technique which has been rather common in agricultural studies is to use the orthodox time study without rating the worker. In other words, the raw data is accepted as it is. Worker A using method No. 1 is compared with worker B using method No. 2. The assumption is made that the output reflects the method differences. It does do that, but it also reflects the worker differences. If worker A is extremely fast and worker B is extremely slow, the most likely result is that method No. 1 will look better than method No. 2. The reverse may be, and often is, true.

The other technique, which is being accepted in industry with considerable hope, is the application of tables of predetermined motion time values. Several tables have been prepared which were based on industrial tasks. The industrial tables have been studied thoroughly and many ideas obtained from them have been helpful in setting up the tables of motions in agricultural marketing operations in this project.

The Time and Skill Tables

The time and skill tables were developed under this project. Both time and skill values are included in these tables. For convenience, the abbreviated title, T&S tables, is used.

The time values given in these tables are average performance times for 15 operators working at normal effort. This is not a rated value. It is simply the arithmetic mean. A fast performance time average is also included, which is representative of the same 15 operators working at high effort. The latter value was used in the evaluation of skill.

The normal time represented in the T&S tables corresponds rather closely in concept with the normal of orthodox time study. It differs mainly in derivation. (The T&S table value is a computed arithmetic mean.) The rater in orthodox time study uses his estimate of mean performance as a basis for his rating.

The 15 workers who made up the sample were, in the main, experienced at the job. About 20 percent were not and these were included for the purpose of noting the differences between data taken from experienced and inexperienced workers. No distinctive characteristic was noted in the data of inexperienced workers. However, they generally required a longer practice period before they could give a smooth performance.

There are eight separate sets of tables based on eight commodity groups identified by appropriate titles. The table values are normal values and not standard times. In order to arrive at a standard time, we must add an allowance to the normal time. Normal time refers to average performance time required when a person is actually performing the specific motions. But a worker does not normally perform these specific motions every minute of the day. There are several classes of delay. Normally these include set-up time, clean-up time, personal time, necessary rest to overcome fatigue, and unavoidable delays. The allowance is not intended to include delays caused by loitering, malingering, or negligence. It is intended to cover the necessary delays.

In selection of the best of alternative motion patterns, the normal time is usually adequate. Ordinarily alternative motion patterns for performing the same task would have the same allowance. The allowance should be used, however, when one alternative would be light manual work and the other heavy manual work. In that case the difference in allowance would be substantial. It is impossible to determine allowances for each motion without consideration of its setting in the overall task. Such allowances not only depend on the particular combination of motions but also on the length of work period, environmental conditions, and the like.

If one needs to compute the standard time, the table of allowances on page 70 of R. M. Barnes' text, Motion and Time Study, is recommended. 2/ This table should be used as a guide rather than as a rule. Sometimes a specific task will deviate widely from normal in one or more of the classes of delay.

Advantages of Using T&S Tables

There are several reasons for using predetermined motion time values in appraisal and selection of methods.

2/ Barnes, Ralph M. Motion and Time Study. John Wiley and Sons, Inc., New York. 1949.

The tables provide for objective appraisal of methods. It does not necessarily follow that the use of such tables will be objective. Prodigious and continuing efforts must be exerted toward making the classifications of motions clear and unmistakable. Ambiguous classes of motions will permit the user to choose either a high or low value for a motion as he sees fit. Furthermore, certain motions might be inserted or left out, depending on the bias of the user. Clearly defined motions have been one of the most important objectives in this project.

The factors which affect motion performance time are highlighted in a good set of tables. In a sense, the tables quantify the principles of motion economy. If the factors which greatly increase performance time are known, they can often be avoided in constructing or revising methods. Thorough familiarity with tables which reflect these factors should provide this knowledge in its most usable form.

Skill evaluations accompany the tables. If the average time requirements for two alternative methods were the same, or very nearly so, the one with the lowest skill requirement would be the most logical choice. More workers would be able to learn to do well the method requiring lower skill and also the average learning period would be shorter. Both of these can be reflected in lower costs. Furthermore, a low-skill method permits a worker to increase output tremendously over short periods of time. In other words, he can speed up. He cannot do this with motion patterns requiring more skill. They do not provide as much flexibility of output. In rush periods, this flexibility of low-skill motion patterns can be quite valuable.

The classifications of motions are of great value in describing methods of instruction and in recording job descriptions. The therbligs originated by Gilbreth have been invaluable for these purposes. 3/

Finally, the tables provide a conveyance for carrying forward the accumulated experience of research done by people in different areas and over the years. The skill of a time study rater, if such skill can be developed, remains with the individual and dies with the individual.

Standard Units of Measure Used in T&S Tables

In order to avoid confusion only one unit of measure has been used for weight, one for time, and one for distance. All weights are expressed in pounds or fractions thereof. All distance measurements are expressed in inches. All time measurements are expressed in winks. The wink corresponds to 1/2000th of a minute. In obtaining the data, the motion picture camera was run at 2,000 frames per minute. Consequently, each frame represents 1/2000th of a minute or a wink. Actual time measurement was accomplished by frame count with frequent checking of the camera speed with an electric microchronometer.

3/ See page 14 for definition of therbligs.

Table 1.--Average actual cycle time for 15 workers performing 14 different motion patterns: time expressed in winks 1/

Motion Pattern	Operator							
	A	B	C	D	E	F	G	H
58	68	64	52	59	54	52	52	53
66	53	48	68	72	54	59	66	63
60	78	72	76	85	63	75	70	69
64	76	80	77	76	66	69	82	62
68	95	87	101	96	76	83	115	82
69	89	88	108	114	79	89	105	95
70	95	118	105	100	91	102	115	91
71	94	112	113	108	94	96	111	93
61	98	90	126	119	80	112	109	118
75	107	93	121	114	89	101	132	106
72	121	136	125	117	98	98	109	99
65	143	149	161	166	110	121	171	118
73	138	134	185	162	112	146	150	141
74	164	154	213	188	155	162	188	195

Table 1. Continued

Motion Pattern	Operator							
	I	J	K	L	M	N	O	All
58	56	52	48	57	54	72	56	57
66	58	54	48	63	54	81	57	60
60	61	58	67	63	63	91	66	70
64	79	65	60	58	66	91	75	72
68	80	71	85	75	98	119	89	90
69	78	70	91	90	95	125	90	94
70	87	76	98	79	103	137	98	100
71	90	79	104	93	107	132	94	101
61	97	94	108	114	90	130	113	106
75	91	86	117	87	105	145	105	107
72	104	87	111	86	117	135	109	110
65	114	106	142	115	123	205	130	138
73	128	113	124	156	143	197	138	144
74	156	130	202	188	180	277	194	183

1/ A wink is 1/2000 of a minute.

Table 2.--Rank correlation of cycle time for 15 workers performing 14 different motion patterns: rank deviations and coefficient of rank correlation

Motion Pattern	Operator														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
58	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
66	1	1	0	0	1	0	0	1	0	0	0	1	0	0	0
60	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0
64	1	0	0	1	0	1	0	2	1	0	1	2	0	0	0
68	3	0	0	0	0	0	4	0	1	1	0	0	2	0	0
69	1	0	1	3	0	0	1	2	2	1	0	3	0	0	0
70	0	3	1	1	2	3	3	1	0	0	0	1	1	3	1
71	1	1	0	1	2	1	0	1	0	0	0	2	2	0	1
61	0	2	2	2	2	2	3	2	1	2	0	2	4	2	2
75	0	2	1	2	2	1	1	0	1	1	1	2	1	1	1
72	0	1	1	1	0	3	4	2	0	1	1	4	0	2	1
65	1	1	0	1	0	0	1	0	0	0	1	0	0	1	0
73	1	2	0	1	0	0	1	0	0	0	1	0	0	1	0
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rank correlation	96	94	98	95	96	94	91	96	98	98	99	90	94	96	98

Skill was measured in two different ways. First, it was derived by correlation analysis. The actual measure used is the coefficient of non-determination. Since this measure did not accomplish all that was expected of it, a second means of measuring skill was developed. The second one is the ratio of fast performance time average to slow performance time average. The rationale of these two skill measures is explained in further detail in the appropriate chapters. Both measures are included in this report.

Decision to Obtain Data from Work Performed Under Uniform Conditions

All of the performance time data for this project were collected in a laboratory. The decision to change from the field operation to the laboratory was made after considerable experience at field work. The reasons for the change are many and vital:

a. Variables such as general layout, distances, work bench height, and quality standards can be kept constant.

b. Laboratory conditions permit control over the workers. They can maintain a pattern of motions long enough to yield reliable data therefrom. Patterns can be changed and workers can practice new ones as long as needed before values are established.

c. Data obtained in the field forces an oversampling of one motion class in relation to others. This is wasteful of expensive film. It is also wasteful of time because the field operation does not operate according to a predictable schedule. Workers often shift patterns or the task is finished before an adequate number of observations are made. Irregular field operations complicate film editing and analyzing.

d. Interruptions are frequent in field work. Filming interrupts the field operation and makes it almost impossible for workers to perform normally.

e. Many operations which needed to be included in the study were machine timed. Under such conditions the operator must make his pace coincide with the rate of the machine. The operator's performance time loses meaning insofar as a table of time data is concerned.

f. In going from one field of operation to another, many differences and important ones are observed in working conditions. These include temperature, light, ventilation, noise, and comfort facilities. While it would be desirable to know the effect of these on performance time, it was impossible to determine this in a 3-year project which must cover a wide variety of motion patterns. The only reasonable alternative was to conduct observations under uniform conditions.

Methodology

Before work was begun on this project, several hundred feet of motion pictures were recorded of apple packing and egg handling operations. Under the project, additional motion pictures were made of: Grading roses, packing tomatoes, packing cauliflower, packing celery, packing onions, packing lettuce, loading celery, packing potatoes, prepackaging coffee, prepackaging macaroni, filling and lidding peanut butter, filling and stitching flour bags, loading bottle washer in milk plant, filling cheese cartons, washing pipe, receiving milk, filling crates of milk, washing milk cans, loading milk cans on truck, unloading milk cans from truck, wrapping and sacking bread, packing doughnuts, packaging meat, packaging cheese, checking out groceries, making up egg cartons, candling eggs, stocking shelves in grocery store, handling cans in canning factory, grading beets, weighing cans of beets, packing cans in case, gluing cases, unloading empty cans from a railroad car, and nailing apple crates.

The films made of field operations listed above were used only for cataloging motions, i.e., selecting, classifying, and detailing motions for further study. They were not used for obtaining performance time data.

As soon as the preliminary selections were made of motion patterns, the equipment was constructed and tested by having a few people run through the motion patterns. Usually two of the project staff went through these tests also in order to get the feel of the work.

These preliminary tests served several purposes:

a. They provided some data upon which to base the choice of class intervals for such factors as weight and distance.
b. They revealed deviations in method which were important and needed to be forestalled in the final runs.
c. They revealed defects in the test equipment which needed correction.
d. They brought up questions concerning other motion patterns which needed to be tested.
e. They showed that some motion patterns were too much alike to be treated as distinctly different classes.
f. They helped to solve the photographic problems while operating on a small scale.

The study developed time and skill requirement values for 342 motions. The value for each motion was based on the carefully recorded performances of 15 experienced operators who performed each motion a minimum of 20 times. These observations were all made on 16 m.m. film exposed at the rate of 2,000 frames per minute. Some 75,220 feet of film (40 frames per foot) were analyzed in the study. Operations involving the handling of roughly round or oblong fruits and vegetables required 19,220 feet of film, bunch vegetables 3,180 feet, eggs 9,050 feet, cans of various shapes and sizes 15,410 feet, glass jars 4,510 feet, glass bottles 4,250 feet, bags 4,760 feet and boxes of various shapes and sizes 14,840 feet.

The handling of these different products of course necessitated the duplication of many motions although specific operations were selected for study for the express purpose of minimizing such duplication. In the final analysis 209 different motions were measured.

Realizing that not every possible combination of factors affecting performance time could be tested, provision was made that portions of the tables might be filled in by interpolation. This expedient was not used except in the "Simplified Tables." In that section, interpolation was used only for the distance factor, and only used then when there appeared to be no danger of discrepancy in using it.

In executing each of the motion patterns which were used for obtaining the table data, the following procedure was followed:

a. The operator was shown the motion pattern.
b. The operator was required to practice this pattern until he became proficient. Proficiency was recognized by the absence of fumbles and a fair degree of speed.
c. The operator was first run through a series of not less than 10 cycles at a normal effort level.
d. The operator was then run through a series of not less than 10 cycles at a high effort level.

The two levels of effort provided the necessary 20 cycles per operator and gave a desirable range in the data for studying the relationship of reach with other motions in the cycle as a measure of skill level. It also forced the individual operators to a more clearly defined concept of normal. If only normal level of effort was asked for, many operators worked at very close to top effort. When they were requested to perform at normal and a decidedly higher effort level, they were forestalled from operating at top effort and calling that normal. Therefore, it is believed that the normal level is considerably more accurately designated herein than is ordinarily obtained when only the one level is asked for.

If one contemplates developing an improved method, he may find the Simplified Tables particularly useful. These tables reflect the causes of differences in time requirements. They do not necessarily reflect the "principles of motion economy" as they are now known. However, the "principle as they are now known are not really principles at all. They are rules of thumb. Some of them have so many exceptions, as they are now stated, that there is considerable doubt that they should be recognized, much less called "principles." The tables exhibit the true nature of relationships. When principles of motion economy are based on actual work measurement, such as the table data, they may come of age.

In setting up the Simplified Tables, numerous adjustments of the actual film analysis data were necessary. In film analysis one will not obtain precisely the same average time each time a motion is repeated. Yet, one cannot have several performance times representing the same motion. The differences are usually small, of course, but they are differences. One value only is needed for a particular motion. In many cases these discrepancies are due to the overlapping nature of basic motions.

The Simplified Tables are called "simplified" for two reasons. First, only one time value is used to represent a particular motion. Second, the time values are adjusted so that each motion carries only the factors for which it is responsible. In film analysis, a reach which precedes a complex grasp will be longer than a reach which precedes a simple grasp. In the simplified version, both reaches will be the same. The extra time for a reach preceding a complex grasp is taken from this reach and added to the complex grasp.

Many adjustments of the type described above were made in constructing the simplified tables. However, no adjustments were made which did not stay within the limits of the actual film analysis data. In order to insure this, each motion pattern for which data were obtained was calculated from the tables. The cycle values obtained in the original film analysis of each motion pattern were then compared with the table value for the motion pattern of that precise description.

The balance of this discussion of methodology is concerned with an evaluation of skill requirements. The first step was to select a base motion which is primarily affected by effort only. A priori reasoning would indicate that reach or move would be the most logical choice. Examination of data confirmed this selection. When effort was increased, these two motions tended to increase more than other motions in the cycle and their increases appeared to correlate very closely with the overall increase in effort as measured by cycle time. The next step was to select between reach and move. Reach was chosen on the basis that it would be least affected by size, weight, and shape of object handled.

Reach is not held to be influenced by effort only, but is believed to be as near that ideal as can be found. An assumption is made at this point which seems to be very well borne out by the data; namely, that the level of effort is, on the average, the same for all motions included within the same cycle. Now if effort is changed, the effect will be most apparent for reach. Thus, reach is taken as a common denominator for effort level for all motion patterns. In other words, reach is an indicator of effort level. If the reach of a given distance takes an unusually short time, then effort level is high, and vice versa. Furthermore, if the changes in some other motion time do not follow the changes in reach time, then some other factor must be influencing this other motion; i.e., something besides effort. These residual effects are identified herein as skill. Insofar as practical measurement is concerned, however, it is sampling error plus skill.

The next step is to obtain a relative measure of these residual effects by correlating each motion in turn with the reach which occurs in the same cycle. Those which correlate the closest are held to be primarily effort motions. When the correlation drops off, it is held that this indicates the presence of skill requirements. The lower the correlation is, the higher the skill requirement must be.

The coefficient of determination (r^2) was used because it more nearly represents the percentage of influence of a factor than does the coefficient of correlation. Therefore, r^2 represents the percentage of variations which are due to effort changes. Since skill is held to be the residual variations which are not accounted for by effort changes, the measure ($1 - r^2$) is used to represent skill. This is called the coefficient of non-determination.

The skill rating of reach is zero by assumption. It is the base or common denominator motion and is assumed to be influenced solely by effort. It was correlated with each of the other individual motions in turn and also with the total cycle.

In theory this measurement of skill and effort seems to be adequate. In practice, the technique breaks down somewhat due to the impossibility of measuring the precise time of each component motion within a cycle. The reach and grasp overlap. Move and position-release overlap. Thus the data which must be used in the correlation cannot be precisely accurate. This causes inaccuracies in the correlation coefficients. What might have been a fairly precise measure of effort and skill is reduced to a rough indicator. Still it offers much refinement over personal judgment alone.

Theoretically, the totals of skill obtained by multiplying the skill factor times the average performance time should be the same for the parts as for the whole. In other words, one could compute in turn the part of each motion which is affected by skill. This computation would be made by multiplying the skill factor times the normal time value. Reach would always be zero because the skill factor for reach is zero. Adding these parts should, theoretically, give the same value as would be obtained by performing the same computation for the cycle skill rating and cycle normal performance time. In actual computation there is always some discrepancy. The total of the parts is almost always somewhat greater than the whole. This is believed to be the result of greater errors of measurement which are incurred in measuring the performance times of the parts; that is, basic motions. Cycle performance time can be measured quite accurately.

Since the technique described above did not prove to be as accurate as was hoped for, other techniques were tried. The one which showed the most reliability was the ratio of fast to normal performance time for the same motion pattern. This measure was applied to the get and place rather than to motion times because of the inaccuracies of measuring independent motion times. The theory for this approach to skill measurement is based on the restrictive effect of skill factors upon the application of effort. It has been noted that as the degree of any identifiable skill factor is increased, the worker must decrease his application of effort or he begins to fumble. In other words, one cannot move as swiftly in performing a precise positioning such as threading a needle as he could if he were putting the thread through a ring one inch in diameter. The ultimate in

skill, according to this measure, would be a ratio of one to one. In other words, the worker could not increase speed at all. This was never observed in actual practice, but for some motion patterns the ratio measure approached this value. Skill requirements which are known are: (1) Perceptual requirements, i.e., the ability to see and to recognize what is seen, (2) precision movements, (3) decision between two or more alternative courses of action, and (4) coordination movements. Since those skill requirements which are readily identified follow this pattern, it seems reasonable to believe that some which are not so easily identified might follow the same pattern.

The above two skill measures combined with the judgment obtained in working with the data provide the basis for the skill evaluations. The judgment portion is mainly based on the length of time the workers required to become reasonably proficient with a given motion pattern. Had data been collected in this area, it would have provided just as objective measurements as the other two but the need for these measurements was not foreseen early enough in this project. Such data would have provided "learning curves" for these motion patterns.

Uses for the T&S Tables

There are several uses which can be made of the table values, other than appraisal of methods. Among these are (1) for production estimates, (2) for budget data, and (3) as a basis for wage payment. The nature of these purposes requires that the data be accurate in an absolute sense. In other words, the allowance must be added to form a standard time.

Production estimates definitely refer to the specific crew which is doing the work. Standards made up from data collected elsewhere are not likely to give as accurate an estimate of the production of a given crew as could be obtained from the performance record of that crew. The same is true of budget data. If performance records of the particular crew are not available, standards such as are presented herein are helpful.

Standards used as a basis for wage payment should reflect the working conditions of the particular task. The T&S table data were taken under good working conditions. If any one of the environmental factors is likely to be detrimental to work performance, that fact should be considered in using the T&S table data.

There are many problems in wage rate setting which simply require that a differential between two similar tasks be set. In other words, one of the tasks has a satisfactory standard. The other task which is very similar does not. Tables such as these may be helpful in determining the correct differential between these two tasks.

Insofar as selection of method is concerned, the tables need only show the correct relative values. A percentage difference will serve just as well as an absolute difference. This fact makes the tables much more

reliable for selection of method than for some of the other uses. Relationships are much more consistent than absolute performance time. In the raw data there are differences which are due to the motion pattern and differences due to the effort level of the worker. If a set of raw data for 15 persons performing 14 different motion patterns is examined, it is rather difficult to see the consistency of relationships. When each individual's data are arranged in the same rank order as the average for all 15 operators and rank deviations computed for each operator 4/, it can be seen quite clearly that there is a high level of consistency in the relationships of one motion pattern to another regardless of who is performing it. The fastest person ranks the motion patterns very nearly the same as the slowest.

This explanation of the superior reliability of relationships over absolute values is not meant to imply that the data herein are not at a satisfactory absolute level. By requiring all operators to work at both a normal pace and a fast pace, it is believed that a better normal was obtained. Some workers tend to speed up when they are timed. The fact that they had to operate at a fast pace as well as at a normal pace restrained this tendency. If they attempted to do the normal pace at too high a speed, they found that they could not speed up for the fast pace. During the practice period each operator was able to adjust the two rates so that the fast was noticeably faster than the normal.

4/ Rank deviations were determined by averaging the time required by all operators to perform a given motion pattern; then ranking the average times for all operators and comparing this ranking with the ranking for each individual operator.

CHAPTER II

BASIC MOTIONS: INVENTORY OF TIME DATA AND CORRELATIONS

The term "basic motion" refers to a level of breakdown commonly referred to as "therbligs" in industrial engineering. It goes a step further than therbligs in that each basic motion is subclassified.

The data contained in this inventory is the direct, unadjusted result of the film analysis. In a few instances, the data of an operator was rejected because of motion pattern deviations. In spite of the controlled conditions, this happened on rare occasions. It is felt that these few operations should be omitted. It is the peculiar advantage of motion picture data collection that such deviators can be discovered and eliminated.

Time values are given in winks. One wink is equal to 1/2000 of a minute.

Basic Motion Data for Round or Oblong Fruits and Vegetables

The data in this section pertains to the handling of fruits and vegetables which are roughly round or oblong in shape. Specifically, the data was taken from the handling of apples, oranges, potatoes, lemons, grapefruit, and cabbage. These commodities were classified according to weight.

The data obtained by holding the motion pattern and weight constant and varying the commodity shows but little change from one commodity to another. This indicates that the data can be used satisfactorily for commodities which are not included but which fit the same shape, size, and weight specifications.

Jumble Pack
Weight 1/4 to 3/4
Pound

In jumble packing the fruit is moved from a bin or belt to a packing crate. No effort is made to place the fruit in a symmetrical pattern. They are simply released in the crate at random.

One hand only used in jumble packing

		Reach	Grasp	Move	Pos-rel	Cycle
MP*2. Apples. Single grasp of one From jumbled on flat surface. Move to crate. Single release. Side reach and move 24"	N	17.7	2.8	18.2	3.1	41.8
	F	11.9	1.3	12.0	1.1	26.3
	C**		.40	.06	.44	.05
MP3. Apples. Single grasp of one. From arranged line of apples on flat surface. Move to crate. Single release. Side reach and move 24"	N	18.8	2.5	18.6	2.9	42.8
	F	11.6	1.1	11.9	1.0	25.6
	C		.18	.06	.45	.02

Two hands used in jumble packing

MP5. Apples. Single grasp one per hand. From jumbled on flat surface. Move to crate. Single release. Side reach and move 24"	N	22.5	3.8	22.9	2.5	51.7
	F	14.0	2.3	14.9	1.3	32.5
	C		.35	.16	.41	.03
MP6. Apples. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 16"	N	20.8	10.4	21.1	3.0	55.3
	F	13.6	6.8	14.4	1.3	36.1
	C		.27	.27	.58	.05
MP7. Apples. Simo grasp two per hand. From arranged pairs on flat surface. Move to crate. Simo release. Side reach and move 24"	N	23.9	6.3	23.4	3.2	56.8
	F	13.9	3.8	15.0	1.6	34.3
	C		.41	.08	.55	.05
MP8. Potatoes. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	21.7	11.4	24.3	2.6	60.0
	F	15.0	8.2	16.4	1.3	40.9
	C		.44	.16	.61	.05
MP9. Lemons. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	22.5	10.2	24.1	3.2	60.0
	F	15.2	8.1	16.7	1.4	41.4
	C		.61	.22	.63	.10

*The letters MP are an abbreviation of Motion Pattern.
**The letter "N" refers to normal rate performance time.
The letter "F" refers to fast rate performance time.
The letter "C" refers to coefficient of non-determination ($1 - r^2$).

			Reach	Grasp	Move	Pos-rel	Cycle
MP10.	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	23.8	10.0	24.9	2.6	61.3
		F	15.3	6.8	16.1	1.5	39.7
		C		.32	.11	.76	.05
MP11.	Oranges. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	22.2	12.7	25.0	3.1	63.0
		F	14.9	8.8	16.8	1.4	41.9
		C		.35	.14	.58	.06
MP12.	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 32"	N	25.6	11.0	27.4	4.0	68.0
		F	17.6	7.6	18.4	1.9	45.5
		C		.39	.15	.60	.07
MP13.	Apples. Pincer grasp two and one half per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	24.2	26.8	24.8	4.4	80.2
		F	17.9	20.5	18.0	2.0	58.4
		C		.56	.36	.53	.23
MP14.	Apples. Two plus one grasp of three per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	23.7	32.4	22.7	3.4	82.2
		F	17.8	24.3	18.7	1.6	62.4
		C		.44	.47	.69	.19

Layer Packing
Weight 1/4 to 3/4 Pound

In layer packing the fruit is grasped from a bin or moving belt and placed in symmetrical rows, lines and layers in the crate. Fruit is oriented so that cheeks are up and cores are parallel to the width of the crate.

One hand only used in layer packing

MP15.	Apples. Single grasp of one. From jumbled on flat surface. Move to single tilt crate. Single position-release. Side reach and move 24"	N	17.1	3.0	18.4	10.6	49.1
		F	12.9	1.6	13.8	6.8	35.1
		C		.53	.31	.47	.16

		Reach	Grasp	Move	Pos-rel	Cycle
MP16. Apples. Simo grasp of two. From jumbled on flat surface. Move to single tilt crate. Consecutive position-release. Side reach and move 24"	N	18.0	10.0	19.0	39.9	87.6
	F	14.5	7.8	15.8	30.5	68.6
	C		.74	.24	.57	.33
Two hands used in layer packing						
MP17. Apples. Single grasp of one per hand. From jumbled on flat surface. Move to double tilt crate. Single position-release. Side reach and move 24"	N	20.3	4.3	22.3	14.3	61.2
	F	14.5	3.1	16.5	9.9	44.0
	C		.92	.18	.57	.19
MP18. Apples. Simo grasp of two per hand. From arranged in pairs on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	22.5	8.5	25.7	50.8	107.5
	F	16.6	5.7	18.9	38.2	79.4
	C		.94	.37	.72	.46
MP19. Apples. Simo grasp of two per hand. From jumbled on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	22.5	12.6	27.8	51.4	114.3
	F	17.4	10.2	21.3	40.3	89.2
	C		.91	.45	.68	.40
MP20. Apples. Simo grasp of two per hand. From jumbled on flat surface. Move to bottom of double tilt crate. Consecutive position-release. Side reach and move 24"	N	23.9	13.2	34.0	53.4	124.5
	F	18.4	9.9	25.1	43.9	97.3
	C		.76	.43	.66	.33
MP21. Apples. Consecutive grasp two per hand. From jumbled on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	22.3	31.5	25.9	51.4	131.1
	F	16.8	21.6	20.7	41.0	100.2
	C		.44	.41	.68	.32
MP22. Apples. Simo grasp two per hand. From jumbled in a box. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	21.4	18.2	33.0	58.5	131.1
	F	17.2	16.3	27.0	45.8	106.3
	C		.99	.78	.97	.83

			Reach	Grasp	Move	Pos-rel	Cycle
MP23. Apples. Consecutive grasp two per hand. From jumbled in a box. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	20.2	38.8	28.2	53.7	140.9
	F	15.9	29.1	22.1	41.7	108.8
	C		.65	.39	.84	.53

Wrapping and Packing
Apples, Weight 1/4
to 3/4 Pound

			Reach	Grasp	Move	Transfer Grasp	Wrap Move	Pos-rel	Cycle
MP120. Apples. Throughout the cycle the work load is heavier for the left hand. Consequently the work of the	N	13.7	2.2	20.4	3.8	42.9	10.3	93.3
	F	11.4	1.6	14.7	2.3	32.2	6.1	68.3
	C		.53	.59	.75	.56	.80	.45

left hand determines the time requirements of the cycle. For that reason, the analysis was based on the motions done by the left hand. Left hand (1) reached to paper dispenser, (2) grasped one tissue, (3) moved to a position over the apples in the crate, (4) transfer-grasped apple from right hand. During this phase of the cycle, the right hand reached to belt, single grasped one apple, moved to left hand, and transfer-released apple onto tissue in left hand. From this point the left hand, assisted by the right hand, (5) wraps tissue around apple and moves it to position in crate, then the left hand (6) positions and releases the wrapped apple in proper position in the crate. After the right hand finishes the wrap motions, it moves toward the belt for another apple. Usually there is a balancing delay at about this point. The right hand must wait or at least slow down while the left hand disposes of the apple in the crate.

Fill Display Bin
From Packing Crate
Weights 1, 2 & 3 Pounds

The grapefruit or cabbage were grasped from a packing crate, moved to a display bin, and released with no effort made to produce a symmetrical pattern in the display bin.

Two hands used to jumble in display bin

			Reach	Grasp	Move	Pos-rel	Cycle
MP24.	Grapefruit. One pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 18"	N	16.9	9.4	23.8	8.4	58.5
		F	11.7	4.9	15.6	2.9	35.1
		C		.39	.51	.56	.16
MP27.	Cabbage. Two pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 18"	N	15.3	13.2	26.0	9.8	64.2
		F	9.6	7.4	16.4	4.8	38.2
		C		.41	.12	.29	.14
MP30.	Cabbage. Three pound. Two hand grasp of one. From jumbled in a box. Move to display bin. Two hand release of one. Front reach and move 18"	N	19.1	7.3	27.8	7.3	61.5
		F	13.6	2.6	17.1	1.7	35.0
		C		.32	.16	.33	.12

Bunch Vegetables

The data for this section was obtained from the handling of celery. Motion Pattern No. 33 was done with an artificial object which was made up to represent a bunch vegetable such as celery. It was thought that this object would not cause any significant difference. However, the data shows a substantial difference. Although the data from this motion pattern is included in the inventory, it was not used in the simplified table for bunch vegetables.

Fill Display Rack From Packing Crate, Weights Approximately 1 & 2 Pounds

The bunch vegetables were grasped from a packing crate, moved to a display rack, and released.

Two Hands Used to Fill Display Rack

			Reach	Grasp	Move	Pos-rel	Cycle
MP33.	Artificial bunch vegetable. One pound. Single grasp of one per hand. From packing crate. Move to display rack. Single release. Reach and move 18"	N	18.0	14.2	31.3	8.8	72.3
		F	12.2	8.6	20.2	4.4	45.4
		C		.85	.74	.89	.43

		Reach	Grasp	Move	Pos-rel	Cycle
MP36. Celery. Two pound. Single grasp of one per hand. From packing crate. Move to display rack. Single release. Reach and move 18"	N	18.4	10.9	31.3	6.3	66.9
	F	11.6	6.0	19.4	2.3	39.3
	C		.44	.15	.39	.12

Eggs

All of the data for this section was taken from the handling of real eggs.

Loading Egg Grader

The eggs were grasped from a filled egg basket, moved to grader track, oriented so that the long axis of the egg lay across the two sides of the grader feed track, positioned on the feed track, and released.

One Hand Only Used in Loading Egg Grader

		Reach	Grasp	Move	Pos-rel	Cycle
MP39. Eggs. Single grasp of one egg. From egg basket. Move to track of egg grader. Single position-release. Front reach and move 12"	N	16.4	5.8	18.8	3.2	44.2
	F	10.9	3.4	12.0	1.7	28.0
	C		.70	.16	.66	.14
MP40. Eggs. Simo grasp of two eggs From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	16.8	16.8	21.8	30.7	86.1
	F	13.0	14.0	15.5	20.0	62.5
	C		.91	.29	.75	.44
MP41. Eggs. Consecutive grasp of two eggs. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	17.1	31.8	21.0	28.2	98.1
	F	12.5	21.3	13.6	17.6	65.0
	C		.34	.25	.33	.19

Two Hands Used in Loading Egg Grader

MP42. Eggs. Single grasp of one egg per hand. From egg basket. Move to track of egg grader. Single position-release. Front reach and move 12"	N	18.8	9.0	22.1	4.1	54.0
	F	12.2	6.0	14.4	1.9	34.5
	C		.89	.34	.78	.34

			Reach	Grasp	Move	Pos-rel	Cycle
MP43.	Eggs. Simo grasp of two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	20.6	22.0	27.3	36.9	106.8
		F	16.6	18.2	19.5	24.3	78.6
		C		1.00	.57	.69	.55
MP44.	Eggs. Consecutive grasp of two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	18.3	39.0	24.2	32.5	114.0
		F	13.2	27.5	16.4	20.7	77.8
		C		.67	.22	.56	.38
MP45.	Eggs. Simo grasp of two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 16"	N	22.1	24.4	31.5	36.6	114.6
		F	16.3	20.7	21.6	24.5	83.1
		C		.96	.37	.53	.32
MP46.	Eggs. Simo grasp of two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Side reach and move 12"	N	27.1	19.6	29.5	38.7	114.9
		F	20.3	17.7	21.4	28.1	87.5
		C		.97	.25	.37	.19
MP47.	Eggs. Simo grasp of two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 24"	N	27.6	24.7	34.6	33.9	120.8
		F	21.3	19.9	25.6	23.7	90.5
		C		.94	.38	.59	.33

Packing Eggs

The eggs were grasped from the bin of an egg grader, moved to filler in an egg crate, oriented so that the pointed end is down, positioned over the cell in the filler, and released.

One Hand Only Used in Packing Eggs

			Reach	Grasp	Move	Pos-rel	Cycle
MP48.	Egg. Single grasp of one egg. From grader bin. Move to case. Single position-release. Front reach and move 12"	N	16.0	5.8	16.0	6.6	44.4
		F	10.8	3.7	11.0	3.6	29.1
		C		1.00	.10	.98	.37

Two Hands Used in Packing Eggs

		Reach	Grasp	Move	Pos-rel	Cycle
MP49. Eggs. Single grasp of one egg per hand. From grader bin. Move to case. Single position-release. Front reach and move 12"	N	19.0	8.4	19.2	7.4	54.0
	F	13.0	5.2	13.3	3.8	35.3
	C		.77	.34	.67	.30
MP50. Eggs. Simo grasp of two eggs per hand. From grader bin. Move to case. Consecutive position-release. Front reach and move 12"	N	22.3	17.0	23.9	37.9	101.1
	F	17.1	13.4	17.6	25.5	73.6
	C		1.00	.60	.97	.78
MP51. Eggs. Consecutive grasp of two eggs per hand. From grader bin. Move to case. Consecutive position-release. Front reach and move 12"	N	19.2	36.1	17.5	31.7	104.5
	F	15.3	26.2	14.7	20.7	76.9
	C		.71	.54	.66	.43
MP52. Eggs. Consecutive grasp of two eggs per hand. From grader bin. Move to bottom of case. Consecutive positon-release. Front reach and move 12"	N	21.4	38.5	25.2	31.5	116.6
	F	14.8	29.6	19.4	21.4	85.2
	C		.40	.15	.44	.20
MP53. Eggs. Simo grasp of three eggs per hand. From grader bin. Move to case. Consecutive position-release of three eggs. Front reach and move 12"	N	24.2	37.6	25.9	72.7	160.4
	F	17.7	30.4	21.1	49.0	118.2
	C		.99	.40	.82	.61
MP54. Eggs. Two plus one grasp of three eggs per hand. From grader bin. Move to case. Consecutive position-release of three eggs. Front reach and move 12"	N	21.8	59.7	20.5	61.1	163.1
	F	18.8	46.3	17.2	43.3	125.6
	C		.76	.63	.88	.63

Weighing Eggs on
Single Egg Scale

Eggs were grasped from an egg basket, moved to the cup of the egg scale, positioned over the cup, and released. Then they were grasped from the scale cup, moved to the other hand and transfer-released.

		Reach	Grasp	Move	Pos-rel	Cycle
MP55. Egg. Single grasp of one egg. From cup of egg scales. Move to other hand. Transfer-release. Front reach and move 12"	N	19.2	3.2	17.1	2.2	41.7
	F	12.5	1.8	11.0	1.1	26.4
	C		.63	.32	.70	.10
MP56. Egg. Single grasp of one egg. From egg basket. Move to cup of egg scales. Single position-release. Front reach and move 12"	N	16.9	5.3	17.9	5.7	45.8
	F	11.2	2.9	12.7	2.0	28.8
	C		.59	.11	.58	.10

Cans

Most of the data in this section was obtained from the handling of No. 303 cans. Some preliminary tests indicated that there would be very little difference in performance time for the buffet, No. 2 and No. 2 1/2 sizes. The No. 303 was selected to represent these smaller sizes. Some motion patterns were done with the 46-ounce juice cans. These showed a substantial difference from the smaller cans.

Stocking Shelves with Cans
Labels Not Oriented

Cans were grasped from case, moved to shelf, positioned over a single layer of cans already on the shelf, and released. No attention was paid to direction of labels.

One Hand Only Used in Stocking Shelf

		Reach	Grasp	Move	Pos-rel	Cycle
MP58. 303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Front reach and move 18"	N	15.2	9.3	23.6	8.5	56.6
	F	11.6	6.4	16.8	3.9	38.7
	C		.52	.29	.59	.20

Two Hands Used in Stocking Shelf

MP60. 303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	17.2	14.1	25.1	14.0	70.4
	F	12.9	9.1	18.2	7.4	47.6
	C		.54	.32	.56	.23

			Reach	Grasp	Move	Pos-rel	Cycle
MP61.	303 can. Simo grasp of two cans per hand. From case. Move to shelf. Simo position-release. Front reach and move 18"	N	17.8	31.3	28.6	28.8	106.5
		F	13.3	20.7	20.1	15.1	69.2
		C		.63	.36	.77	.41
MP62.	46-ounce can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	18.9	15.2	31.6	12.6	78.3
		F	12.0	9.5	20.3	6.3	48.1
		C		.46	.10	.48	.13

Stocking Shelves with Cans
Labels Oriented to Face Customers

Cans were grasped from case, moved to shelf, labels oriented so that they faced outward from the shelf, positioned over a single layer of cans already on the shelf, and released.

One Hand Only Used in Stocking Shelves

MP64.	303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Front reach and move 18"	N	15.3	10.4	27.7	18.7	72.1
		F	12.1	7.7	19.6	11.1	50.5
		C		.56	.66	.74	.38
MP65.	303 can. Simo grasp of two cans. From case. Move to shelf. Single position-release. Front reach and move 18"	N	16.3	24.1	28.1	69.9	138.4
		F	13.0	20.6	21.9	46.4	101.9
		C		.84	.38	.60	.48

Two Hands Used in Stocking Shelves

MP66.	303 can. Transfer grasp of one can. From left hand. Move to shelf. Single position-release. Front reach and move 18" (the cans were obtained from case by the left hand).	N	18.3	7.8	20.1	13.7	59.9
		F	14.4	4.9	14.5	9.2	43.0
		C		.83	.91	.98	.60
MP67.	303 can with 2-faced label. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	17.9	13.6	31.3	14.9	77.7
		F	12.6	10.2	21.1	8.5	52.4
		C		.63	.19	.47	.15

			Reach	Grasp	Move	Pos-rel	Cycle
MP68.	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 12"	N	14.5	16.5	26.7	32.5	90.2
		F	11.0	11.4	17.9	21.8	62.1
		C		.71	.75	.66	.39
MP69.	303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Front reach and move 18"	N	17.3	15.2	32.5	28.7	93.7
		F	13.0	11.1	22.8	20.0	66.9
		C		.47	.61	.57	.21
MP70.	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	19.6	18.3	33.8	28.1	99.8
		F	14.6	12.3	25.3	20.0	72.2
		C		.49	.68	.62	.26
MP71.	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Side reach and move 24"	N	22.3	14.6	35.9	28.6	101.4
		F	16.2	10.6	27.5	20.2	74.5
		C		.75	.48	.65	.17
MP72.	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	25.1	15.3	41.1	28.7	110.2
		F	19.2	11.7	31.5	21.8	84.2
		C		.55	.49	.68	.25
MP73.	303 can. Simo grasp of three cans with both hands. From case. Move to shelf. Use both hands to position-release. Front reach and move 18"	N	17.5	25.8	33.1	68.1	144.5
		F	13.7	19.4	24.4	55.5	113.0
		C		.65	.40	.68	.38
MP74.	303 can. Simo grasp of two cans per hand. From case. Move to shelf. Consecutive position-release. Front reach and move 18"	N	17.4	30.1	33.1	102.4	183.0
		F	14.0	24.7	25.6	80.8	145.1
		C		.65	.38	.66	.47
MP75.	46-ounce can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	17.3	19.2	29.6	40.5	106.6
		F	13.2	12.8	23.0	29.0	78.0

Glass Jars

The data in this section was obtained from the handling of pint and quart glass jars. All data was taken from two handed operation.

Stocking Shelves with Jars
Labels Not Oriented

Jars were grasped from a case which had a cardboard separator in it, forming an individual cell for each jar, moved to shelf, positioned on shelf, and released. No attention was paid to the direction of labels.

Two Hands Used to Stock Shelves

		Reach	Grasp	Move	Pos-rel	Cycle
MP76. Pint glass jar. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	18.5	14.8	30.2	9.8	73.3
	F	11.2	10.2	18.7	3.8	44.0
	C		.50	.14	.25	.10
MP79. Quart glass jar. Single grasp of one jar per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	17.0	15.3	34.9	11.2	78.4
	F	11.0	10.8	24.0	5.3	51.1
	C		.37	.11	.38	.11

Stocking Shelves with Jars
Labels Oriented to Face Customers

Jars were grasped from a case which had a carboard separator in it forming an individual cell for each jar, moved to shelf, oriented so that jar labels faced outward from shelf, positioned on shelf and released.

Two Hands Used to Stock Shelves

MP82. Pint glass jar. Single grasp of one jar per hand. From case. Move to shelf. Front reach and move 18"	N	16.8	17.9	30.0	32.4	97.1
	F	12.8	13.3	21.5	21.6	69.2
	C		.46	.46	.59	.24

Glass Bottles

The data in this section was obtained from the handling of seven-ounce soft drink bottles and quart milk bottles.

Stocking Shelves with Bottles
Labels Not Oriented

The seven-ounce bottles were grasped from a wooden case without separators. The quart milk bottles were grasped from a metal crate with metal separators which formed an individual cell for each bottle. Bottles were moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves

		Reach	Grasp	Move	Pos-rel	Cycle
MP83. Seven-ounce bottle. Single grasp of one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	18.9	9.7	34.6	11.3	74.5
	F	12.3	5.5	22.0	5.3	45.1
	C		.41	.14	.36	.11
MP86. Quart milk bottle. Single grasp of one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	16.9	11.7	37.2	14.1	79.9
	F	10.6	6.1	24.1	7.3	48.1
	C		.27	.18	.41	.11

Stocking Shelves with Bottles
Labels Oriented to Face Customers

Seven-ounce bottles were grasped from a wooden case without separators, moved to shelf, oriented so that labels faced outward from the shelf, positioned on the shelf, and released.

Two Hands Used to Stock Shelves

MP89. Seven-ounce bottle. Single grasp of one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	19.5	9.5	38.6	19.2	86.8
	F	14.4	6.0	27.8	13.8	62.0
	C		.34	.40	.83	.28

Bags

The data in this section was taken from the handling of one-pound paper bags, two-pound paper bags, and 25-pound burlap bags. All of the data was taken from two handed operations.

Stocking Shelves with Bags
Labels Not Oriented

Bags were grasped from a case, moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves

			Reach	Grasp	Move	Pos-rel	Cycle
MP90.	One-pound bag. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	16.9	18.9	26.7	10.5	73.0
		F	10.9	10.9	16.3	5.7	43.8
		C		.42	.13	.59	.06
MP93.	Two-pound bag. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	16.0	20.5	27.8	9.1	73.4
		F	10.6	11.6	17.0	4.0	43.2
		C		.33	.18	.38	.14

Stocking Shelves with Bags
Labels Oriented to Face Customers

Bags were grasped from a case, moved to shelf, oriented so that labels faced outward from the shelf, positioned on the shelf, and released.

Two Hands Used to Stock Shelves

MP96.	One-pound bag. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	17.3	19.5	30.0	21.0	87.8
		F	12.4	14.4	22.3	13.0	62.1
		C		.62	.27	.37	.15

Moving Large Bags
From Stack to Conveyor

Bags were grasped from a stack, moved horizontally from left to right, and released on a conveyor.

Two Hands Used to Load Conveyor

MP97.	25-pound bag. Grasp one with both hands. From stack. Move to conveyor. Single release. Side reach and move 24"	N	19.4	14.0	28.2	7.9	69.5
		F	11.4	6.0	17.2	3.5	38.1
		C		.35	.19	.33	.11

Boxes

The data in this section was obtained from the handling of boxes of the following weights: 1/2 pound, 1 pound, 2 1/2 pound, 5 pound, 10 pound, 25 pound and 50 pound.

Stocking Shelves with Boxes
Labels Not Oriented

Boxes were grasped from a case, moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves

		Reach	Grasp	Move	Pos-rel	Cycle
MP98. 1/2-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	15.2	17.8	24.8	13.7	71.5
	F	9.5	10.4	14.2	5.9	40.0
	C		.29	.12	.35	.13
MP101.1-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	15.7	17.0	27.0	13.5	73.2
	F	10.1	9.9	15.9	6.0	41.9
	C		.47	.24	.58	.24
MP104.2 1/2-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	14.3	18.3	27.8	14.2	74.6
	F	9.1	9.4	16.2	5.9	40.6
	C		.44	.18	.46	.20
MP107.5-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	14.0	21.5	32.5	16.1	84.1
	F	9.1	12.7	20.9	6.5	49.2
	C		.47	.19	.54	.22

Stocking Shelves with Boxes
Labels Oriented to Face Customers

Boxes were grasped from a case, moved to shelf, oriented so that labels faced outward from shelf, positioned on shelf, and released.

Two Hands Used to Stock Shelves

			Reach	Grasp	Move	Pos-rel	Cycle
MP110.	1/2-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	16.7	17.0	28.9	18.4	81.0
		F	12.5	13.3	20.3	12.2	58.3
		C		.58	.43	.71	.31
MP111.	1-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	15.9	17.3	30.6	20.2	84.0
		F	12.7	12.8	23.7	12.6	61.8
		C		.45	.32	.72	.28
MP112.	2 1/2-pound box. Single grasp of one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	14.0	18.4	30.3	23.0	85.7
		F	10.7	13.3	22.3	14.9	61.2
		C		.61	.38	.73	.43
MP113.	5-pound box. Single grasp of box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	15.8	23.5	37.9	28.9	106.1
		F	11.7	15.4	27.9	18.0	73.0
		C		.43	.27	.69	.35

Move Large Boxes From
Stack to Conveyor

Boxes were grasped from a stack, moved horizontally from left to right, and released on a conveyor.

Two Hands Used to Load Conveyor

MP114.	10-pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 18"	N	19.2	9.3	24.4	6.0	58.9
		F	11.4	3.9	14.4	2.3	32.0
		C		.49	.12	.44	.10
MP115.	10-pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 24"	N	20.6	9.5	26.2	5.5	61.8
		F	12.0	3.6	15.9	2.5	34.0
		C		.58	.17	.45	.13
MP116.	25-pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 24"	N	22.1	14.2	34.6	7.4	78.2
		F	14.5	6.1	22.3	3.0	45.9
		C		.42	.16	.43	.10

			Reach	Grasp	Move	Pos-rel	Cycle
MP117.	25-pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 36"	N	25.2	14.8	36.7	8.0	84.7
		F	17.0	5.6	24.2	3.4	50.2
		C		.39	.23	.50	.13
MP118.	25-pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 48"	N	29.1	16.8	39.2	9.9	95.0
		F	18.8	8.2	27.0	5.4	59.4
		C		.22	.25	.38	.08
MP119.	50-pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 24"	N	21.5	17.3	39.3	10.6	88.7
		F	13.9	8.9	26.0	4.7	53.5
		C		.48	.24	.44	.16

CHAPTER III

BASIC MOTIONS: EVALUATION OF SKILL IN GRASPS

If one considers only hand work which occurs at a fixed work place, all motions fit fairly well into two broad classes. There is one class in which the hands travel, and it is exemplified by the motions reach and move. There is another class in which the hands manipulate, and it is exemplified by grasp, orient, position, and release. This excludes the therblig classes of hold, rest, and delay which do not represent motions in the real sense of the word.

The travel motions are governed largely by effort. A person can change the rate of performance of reach and move instantaneously over a a wide range simply by voluntary decision.

The manipulative motions are governed to some extent by effort, also, but not in the same degree as the travel motions. In performing manipulative motions, one cannot increase speed very far before he begins to fumble. The more precise and complex the manipulation, the quicker one will arrive at the fumbling stage. One cannot go beyond this stage simply by voluntary decision. He must practice for a while. This restrictive effect is called skill. The more skill content there is in a motion, the greater will be the restriction in the application of effort.

Both of the motions reach and move respond quite readily to increases in effort. However, the rate of performing a move can be restricted somewhat by the size, weight and shape of the object moved. Since this limitation does not apply to reach, the motion reach was selected as the best indicator of effort level.

Reach responds most readily to increases in effort. All other motions respond to increases in effort but the more skill content a motion has, the less it responds. By comparing the response of reach to changes in effort with the response of another motion which occurred in the same cycle, a measure of effort was obtained. Reach was the standard. The technique of measurement was correlation analysis.

In order to provide the raw material for the correlation analysis, performance time averages for a given motion pattern had to be obtained at different levels of effort. Then, the reach time and grasp time of the same sample of cycles were paired for the correlation.

The measurements were made in terms of the coefficient of determination (r^2). The coefficient of determination was used because it is the statistical measure which most nearly represents the proportion of influence. In this instance, it was an attempt to measure the proportion of the variability of a particular motion which could be accounted for by level of effort.

The measurement of skill and effort by this technique has been only partly successful. The theory appears to be sound but there are inaccuracies in the measurement of basic motions which tend to obscure the exact relationship. The motions reach and grasp actually overlap in varying degrees. There is no point at which reach clearly ends and grasp begins. The same is true of move and position. Consequently the film analysis to obtain performance times for these motions is not and cannot be precisely accurate.

Each person in the sample of 15 operators performs the motion pattern 10 times at two different levels of effort. This provides 30 pairs of data upon which to base the correlation. The coefficient of determination measures the influence of effort. Variations in the performance time which are not accounted for by differences in effort level are identified as being due to skill requirements. When working conditions are held constant, this identification of skill as the residual after removing the effect of effort seems logical. However, in addition to skill, the residual also contains the effect of statistical discrepancies. These discrepancies are due to inaccuracy of measurement in obtaining the basic data.

The actual measure used to evaluate skill is called the coefficient of non-determination. It is obtained by subtracting the coefficient of determination from one ($1-r^2$). This measure simply inverts the coefficient of determination, permitting the presentation of the skill measurement as a direct relationship.

The correlation measurement applied to individual basic motions can not be relied upon to indicate skill content except in terms of group averages. Individual coefficients deviate widely. This is shown clearly when comparing coefficients for replicated motions. In these cases one would expect the coefficient to remain the same, but such was frequently not the case. At least in some degree, these results cast a shadow upon the validity of film analysis broken down to the level of basic motions.

For each motion pattern, the coefficient was also computed for reach paired with the cycle time. There was no difficulty in obtaining a highly accurate measure of cycle time. This coefficient appears to be much more reliable and much more sensitive to changes in skill content than those based on basic motions. Even for evaluating a single basic motion it appears to be better than the coefficients obtained from reach paired with that basic motion.

The deficiencies of measuring skill by correlation were noted some months ago and a better means for measuring skill was sought. Fortunately a more sensitive measure was found, but it should not be applied to the basic motion level of work subdivision. It was applied to the get and place breakdown and is included in that section of the report. The new skill measure appears to be more sensitive to changes in skill content and is far simpler and cheaper to obtain than the coefficient of non-determination.

Skill Evaluations for the Round or Oblong Fruit and Vegetable Motion Time Data

The skill evaluations are first made within the group of motion patterns which apply to one work operation. For example, jumble packing of fruits from 1/4 to 3/4 pounds in weight is considered to be an independent group. Factors which apply to another weight class or to layer packing are not pertinent to this operation except in an academic examination of factors. Some discussion is presented in the summary sections of intra operation comparisons.

Inventory of Data

Grasps Which Occur in Jumble Packing Fruits 1/4 to 3/4 Pound in Weight:

		CND* Grasp
MP2	One hand single grasp of one apple from jumbled on a flat surface. Reach 24"	.40
MP3	One hand single grasp of an apple from an arranged line on a flat surface. Reach 24"	.18
MP5	Two hand single grasp of one apple per hand from jumbled on a flat surface. Reach 24"	.35
MP6	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 16"	.27
MP7	Two hand simo grasp of two apples per hand from arranged pairs on a flat surface. Reach 24"	.41
MP8	Two hand simo grasp of two potatoes per hand from jumbled on a flat surface. Reach 24"	.41
MP9	Two hand simo grasp of two lemons per hand from jumbled on a flat surface. Reach 24"	.61
MP10	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.32
MP11	Two hand simo grasp of two oranges per hand from jumbled on a flat surface. Reach 24"	.35
MP12	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.39

*Coefficient of non-determination

		CND* Grasp
MP13	Two hand pincer grasp of two and a half apples per hand from jumbled on a flat surface. Reach 24"	.56
MP14	Two hand two plus one grasp of three apples per hand from jumbled on a flat surface. Reach 24"	.44
MP15	One hand single grasp of one apple from jumbled on flat surface. Reach 24"	.53
MP16	One hand simo grasp of two apples from jumbled on flat surface. Reach 24"	.74
MP17	Two hand single grasp of one apple per hand from jumbled on flat surface. Reach 24"	.92
MP18	Two hand simo grasp of two apples per hand from arranged in pairs on a flat surface. Reach 24"	.94
MP19	Two hand simo grasp of two apples per hand from jumbled on flat surface. Reach 24"	.91
MP20	Two hand simo grasp of two apples per hand from jumbled on flat surface. Reach 24"	.76
MP21.	Two hand consecutive grasp of two apples per hand from jumbled on flat surface. Reach 24"	.44
MP22	Two hand simo grasp of two apples per hand from jumbled in a box. Reach 24"	.99
MP23	Two hand consecutive grasp of two apples per hand from jumbled in a box. Reach 24"	.65

Grasps Used in Stocking Fruit or Vegetable Bin From Packing Crate, Weights of Approximately 1, 2 and 3 Pounds:

		CND* Grasp
MP24	Two hand single grasp of one pound grapefruit per hand from jumbled in a box. Reach 18"	.39
MP27	Two hand single grasp of one two-pound cabbage per hand from jumbled in a box. Reach 18"	.41
MP30	Grasp one three-pound cabbage with both hands from jumbled in a box. Reach 18"	.32

*Coefficient of non-determination

Evaluation of Skill

The following evaluations are based on the coefficients of non-determination derived by correlating each particular class of grasps with the reaches which occurred in the same cycle.

One Hand Versus Two Hand: Occasionally one will observe a worker employing only one hand in the performance of his work.

		CND Grasp
MP2	One hand (jumble pack)	.40
MP5	Two hand (jumble pack)	.35
MP15	One hand (layer pack)	.53
MP17	Two hand (layer pack)	.92
MP16	One hand (layer pack)	.74
MP19	Two hand (layer pack)	.91

The data indicates that in jumble packing, it made little difference whether one used one hand or both hands so far as skill is concerned. In layer packing, the data indicates that more skill is needed for two-hand work.

Grasp Types Used in Jumble Packing: All of the grasps in this series were made from a flat surface such as the bottom of a packing bin or moving belt. The single grasp refers to a simple grasp of only one object. The simo grasp refers to the grasping of two objects simultaneously. Where two objects are separated by a few inches, the first one is slid along the surface until the two are adjacent before the grasp is completed. The grasp is performed as nearly simultaneously as is possible. The pincer grasp refers to a simo grasp of two apples per hand, followed by grasping another between the middle fingers of the two hands. Both hands grasp a total of five objects in the pincer grasp. The two-plus-one grasp refers to a three object grasp. First, two objects are grasped simultaneously, then a third is obtained by placing the middle finger over it and holding it against the first two.

		CND Grasp
MP5	Single grasp	.35
MP10	Simo grasp	.32
MP13	Pincer grasp	.56
MP14	Two-plus-one-grasp	.44

The simo grasp shows a lower proportion of skill than the single grasp; however, the total amount of skill required by a simo grasp would be greater because the proportion refers to a much longer performance time. Even more skill was required in the other two motion patterns (MP13 and MP14) where more than two apples were grasped per hand.

Grasps Used in Layer Packing: Some of the grasps were made from a flat surface such as the bottom of a bin or a moving belt. Some were made from fruit jumbled in depth such as one would find in a filled bin or box.

The single grasp refers to a simple grasp of one apple. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the first apple, then a second grasp of another apple with the same hand. The simo grasp refers to the simultaneous grasp of two apples in the same hand. In actual practice, the simo grasp was not always completely simultaneous because one apple would be a few inches from the other. In such cases, the first apple would be slid along until the second could be grasped.

		CND Grasp
MP17	Single grasp (from flat surface)	.92
MP21	Consecutive grasp (from flat surface)	.44
MP19	Simo grasp (from flat surface)	.91
MP23	Consecutive grasp (from box)	.65
MP22	Simo grasp (from box)	.99

The single grasp shows a high proportion of skill but this does not indicate a large amount of skill because the proportion refers to a very short performance time. The lowest proportion of skill is indicated for the consecutive grasps. That is logical because a part of the consecutive grasp is a reach to the second apple to be grasped. This reach portion is obviously low in skill. The simo grasp has a higher proportion of skill than the consecutive grasp but the spread is even wider

when the grasps were made from a box; that is, from fruit jumbled in depth.

Fruit Arranged in Uniform Pattern Versus Jumbled: The fruit on a packing belt would be in jumbled order. In order to determine what effect this random arrangement had, an artificially uniform and symmetrical arrangement was set up. The fruit was spread evenly in a straight line, either singly or in pairs.

		CND Grasp
MP3	Arranged (jumble pack, single grasp)	.18
MP2	Jumbled (jumble pack, single grasp)	.40
MP7	Arranged (jumble pack, simo grasp)	.41
MP10	Jumbled (jumble pack, simo grasp)	.32
MP18	Arranged (layer pack, simo grasp)	.94
MP19	Jumbled (layer pack, simo grasp)	.91

Grasps of jumbled fruit invariably take longer to perform than grasps of arranged fruit; however, the proportion of skill involved in grasps of jumbled fruit is lower, except in the case of single grasps.

Different Commodity of About Same Size and Weight: Although the main body of data in this section was obtained from the handling of apples, it was intended to serve for other fruits or vegetables of a similar size, shape, and weight. In order to see whether the data actually could be used for other commodities, several others were tried for comparison.

		CND Grasp
MP10	Apple	.32
MP11	Orange	.35
MP8	Potato	.44
MP9	Lemon	.61

The other three commodities required more skill in grasps than apples. Oranges were nearest to apples in skill, perhaps because they were nearest in shape. The potatoes and lemons were oblong in shape, which very likely caused grasps of them to be higher in skill requirements.

Jumbled on a Flat Surface Versus Jumbled in Depth: Sometimes the grasps are made from a flat surface such as the bottom of a packing bin or from a moving belt. In other cases the fruit is grasped from a filled bin or field crate and is jumbled in depth.

		CND Grasp
MP21	Flat surface	.44
MP23	Depth	.65
MP19	Flat surface	.91
MP22	Depth	.99

The data shows that decidedly more skill is required in making grasps where the fruit is jumbled in depth.

Top of Crate Versus Bottom of Crate: In both cases, the distance was the same. The factor which is measured here is the change of direction which occurs in the reach when packing in the bottom of the crate.

		CND Grasp
MP19	Top of crate	.91
MP20	Bottom of crate	.76

There is an apparent discrepancy in this data. The grasps involved are alike but the change of direction may have introduced some skill into the reach in MP20. On the other hand, the added time required to perform the reach when the change of direction occurred (MP20) may have given more time for selecting the apples to be grasped, thus lessening the skill necessary during the actual performance of the grasp.

The Distance Factor: Within the following series of motion patterns, distance was the only factor which varied.

		CND Grasp
MP6	16 inch (apple)	.27
MP10	24 inch (apple)	.32
MP12	32 inch (apple)	.39

The data indicates a definite increase in skill as distance increased. This is logical because control lessens as the hand is extended farther from the body.

Summary

In jumble packing there was but little difference between one hand and two hand grasps. In layer packing the two hand grasps required more skill.

In jumble packing, the single and simo grasps show virtually the same proportion of skill; however, the skill content of the simo grasp is greater because the proportion refers to a longer performance time. Even more skill was required for the pincer and two-plus-one grasps.

In layer packing both the single and simo grasp show a very high proportion of skill. The skill content of the simo grasp is considerably greater because it refers to a longer performance time. The skill proportion of the consecutive grasp is somewhat lower. This is to be expected because a portion of the consecutive grasp consists of a reach to the second apple to be grasped. The reach portion is obviously low in skill.

Grasps of jumbled fruit invariably take longer to perform than grasps of arranged fruit; however, the proportion of skill involved in grasps of jumbled fruit is lower except in the case of single grasps.

Oranges, potatoes and lemons require more skill to grasp than apples, although oranges were very little different. The potatoes and lemons were oblong in shape, which very likely caused grasps of them to be higher in skill requirements.

Grasps of fruit jumbled in depth, such as fruit in a filled bin or box, definitely required more skill than grasps of fruit from a flat surface.

There was a definite increase in skill as distance increased. This is logical because control lessens as the hand is extended farther from the body.

Bunch Vegetables

There is no skill factor represented in the motion patterns used in handling bunch vegetables.

Inventory of Data

		CND Grasp
MP33	Two-hand single grasp of a one-pound artificial bunch vegetable per hand from a packing crate. Reach 18"	.85
MP36	Two-hand single grasp of a two-pound celery per hand from a packing crate. Reach 18"	.44

Evaluation of Skill

There were no matched pairs for evaluation of skill in the handling of bunch vegetables. The general indications are that skill requirements are low. The artificial bunch vegetable required more skill to grasp than the real celery.

Eggs

The additional factor of fragility is introduced in egg handling. It is quite apparent in observing the work that fragility is of considerable importance.

Inventory of Data

Grasps Which Occur in Loading Egg Graders:

		CND Grasp
MP39	One hand single grasp of one egg from egg basket. Reach 12"	.70
MP40	One hand simo grasp of two eggs from egg basket. Reach 12"	.91
MP41	One hand consecutive grasp of two eggs from egg basket. Reach 12"	.34
MP42	Two hand single grasp of one egg per hand from egg basket. Reach 12"	.89
MP43	Two hand simo grasp of two eggs per hand from egg basket. Reach 12"	1.00

		CND Grasp
MP44	Two hand consecutive grasp of two eggs per hand from egg basket. Reach 12"	.67
MP45	Two hand simo grasp of two eggs per hand from egg basket. Side reach 12"	.96
MP46	Two hand simo grasp of two eggs per hand from egg basket. Side reach 12"	.97
MP47	Two hand simo grasp of two eggs per hand from egg basket. Reach 24"	.94

Grasps Which Occur In Packing Eggs:

MP48	One hand single grasp of one egg from grade bin. Reach 12"	1.00
MP49	Two hand single grasp of one egg per hand from grader bin. Reach 12"	.77
MP50	Two hand simo grasp of two eggs per hand from grader bin. Reach 12"	1.00
MP51	Two hand consecutive grasp of two eggs per hand from grader bin. Reach 12"	.71
MP52	Two hand consecutive grasp of two eggs per hand from grader bin. Reach from bottom of case 12"	.40
MP53	Two hand simo grasp of three eggs per hand from grader bin. Reach 12"	.99
MP54	Two hand two-plus-one grasp of three eggs per hand from grader bin. Reach 12"	.76

Grasps Used in Weighing Eggs on a Single Egg Scale:

		CND Grasp
MP55	One hand single grasp of one egg from cup of egg scales. Reach 12"	.63
MP56	One hand single grasp of one egg from egg basket. Reach 12"	.59

Evaluation of Skill

The following evaluations of skill take into account method variations which affect skill content and those which do not. The evaluations are based on matched pairs and matched series.

One Hand Versus Two Hand: Frequently one observes a person working with only one hand. These data provide a measure of skill for such an operation compared to the usual two hand work.

		CND Grasp
MP39	One hand (grading)	.70
MP42	Two hand (grading)	.89
MP41	One hand (grading)	.34
MP44	Two hand (grading)	.67
MP40	One hand (grading)	.91
MP43	Two hand (grading)	1.00
MP48	One hand (packing)	1.00
MP49	Two hand (packing)	.77

In all three of the pairs which were from grading motion patterns, two hand work required more skill than one. In the packing motion pattern, the relation was reversed.

Grasps Used in Egg Grading: Several types of grasps are used in grading. All of these were made from an egg basket. The single grasp refers to a simple grasp of one egg. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the egg and then a grasp of another egg. The simo grasp refers to the simultaneous grasping of two eggs at a time in the same hand. In actual performance, the grasp is not always completely simultaneous. If one egg is a few inches from the other, the first is caught near the little finger and heel of the hand, then the hand is moved over to grasp a second egg as nearly simultaneously as can be done.

		CND Grasp
MP39	Single (one hand)	.70
MP41	Consecutive (one hand)	.34
MP40	Simo (one hand)	.91
MP42	Single (two hand)	.89
MP44	Consecutive (two hand)	.67
MP43	Simo (two hand)	1.00

In each series the simo grasp showed the highest proportion of skill. The simo grasp showed an even higher proportion of skill when both hands were used. The consecutive grasp showed the lowest proportion of skill. This is to be expected in view of the fact that a portion of the consecutive grasp is a short reach to the second egg to be grasped. This reach portion is obviously low in skill content. The single grasp shows a relatively high proportion of skill but this proportion refers to a very short performance time; therefore, the skill content of a single grasp is rather small.

Grasp Types Used in Egg Packing: All of the grasps used in packing eggs were made from the bin of an egg grader. These were grasps from a flat surface. The single grasp refers to a simple grasp of one egg. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the egg and then a grasp of another egg. The simo two grasp refers to the simultaneous grasping of two eggs at a time in the same hand. In actual performance the grasp is not always completely simultaneous. If one egg is a few inches from the other, the first egg is caught near the little finger and heel of the hand, then the hand is moved over to grasp the second egg as nearly simultaneously as can be done. The simo three grasp refers to the simultaneous grasping of three eggs in a hand. Like the simo two grasp, it is not always done completely simultaneously but it is as nearly simultaneous as possible. The two-plus-one grasp refers to a simo grasp of two eggs in a hand followed by a regrasp, then a single grasp of a third egg.

		CND Grasp
MP49	Single grasp (two hand)	.77
MP51	Consecutive grasp (two hand)	.71
MP50	Simo grasp (two hand)	1.00
MP53	Simo three grasp (two hand)	.99
MP54	Two-plus-one grasp (two hand)	.76

The simo two and simo three grasps were the highest in skill proportion, both being about equal. The consecutive grasp and two-plus-one grasp were lowest in skill proportion. Both of these grasps entail a short reach between grasps. This reach portion is obviously low in skill, tending to lower the skill proportion of the whole grasp. The single grasp was relatively high in skill proportion but the proportion refers to a very short performance time, making the skill content of single grasps rather low.

Source From Which Egg is Grasped: Eggs were grasped from an egg basket where they were jumbled in depth, from a grader bin where they rested on a flat surface, and from the cup of single-egg scale.

		CND Grasp
MP39	Egg basket (single grasp)	.70
MP55	Cup of egg scale (single grasp)	.63
MP42	Egg basket (single grasp)	.89
MP49	Grader bin (single grasp)	.77
MP44	Egg basket (consecutive grasp)	.67
MP51	Grader bin (consecutive grasp)	.71
MP43	Egg basket (simo grasp)	1.00
MP50	Grader bin (simo grasp)	1.00

Apparently less skill was required in grasping an egg from the cup of a single egg scale than was required in grasping an egg from a filled egg basket. This is probably due to the fact that no selection is necessary when grasping from the scale cup; whereas, selection is a necessary part of grasps from an egg basket.

The data does not indicate clearly whether grasps from a basket or grasps from a bin require more skill.

Change of Direction in Reach: When eggs were packed in the bottom of the case, a change of direction occurred in the reach. This change of direction in reach does not occur when packing in the top of the case.

		CND Grasp
MP51	No change of direction	.71
MP52	Change of direction	.40

There is an apparent discrepancy in this data. The grasps involved are alike but the change of direction may have introduced some skill into the reach in MP52. On the other hand, the added time required to perform the reach when the change of direction occurred (MP52) may have given more time for selecting the eggs to be grasped, thus lessening the skill necessary during the actual performance of the grasp.

Front Versus Side Reach: A work place can be set up so that reaches are to the front or it can be set up so that reaches are to the side.

		CND Grasp
MP43	Front reach	1.00
MP46	Side reach	.97

The data shows a very small difference in skill between grasps coming after front reaches and grasps coming after side reaches. It is doubtful that this difference is significant.

The Distance Factor: This series varied only in distance of reach.

		CND Grasp
MP43	12 inches	1.00
MP45	16 inches	.96
MP47	24 inches	..94

The data indicates that skill decreased as distance increased. None of the reaches used in handling eggs were very long. It seems likely that t two shorter reaches did not last long enough for the eyes to complete the selection of the next eggs to be grasped, thus putting a part of select into grasp. This would add to the skill requirements of grasp.

Summary

In grading, two hand work required more skill. In packing, this relation was reversed.

In both grading and packing, the simo grasp required the most skill and the consecutive grasp the least. The single grasp required a high proportion of skill but this proportion refers to a very short performance time; thus, the total skill content of single grasps is small.

Less skill was required in grasping an egg from the cup of a single egg scale than was required in grasping an egg from a filled egg basket. The data does not indicate clearly whether grasps from a basket or grasps from a bin require more skill.

The grasps which accompanied the shorter reaches required more skill than the grasp following a 24-inch reach. This is reasonable to expect since the shorter reaches do not give sufficient time for the eyes to select eggs for grasping, and select is added to the grasp.

Cans

In addition to the different types of grasp, the handling of cans introduces a type of orienting which is most certainly a skill factor. Cans are usually oriented on the shelf so that labels face outward.

Inventory of Data

Stocking Shelves with Cans--Labels Not Oriented:

		CND Grasp
MP58	One hand single grasp of a 303 can from case. Reach 18"	.52
MP60	Two hand single grasp of a 303 can per hand from case. Reach 18"	.54
MP61	Two hand simo grasp of two cans per hand from case. Reach 18"	.63
MP62	Two hand single grasp of a 46 oz. can per hand from case. Reach 18"	.46

Stocking Shelves with Cans--Labels Oriented to Face Customers:

		CND Grasp
MP64	One hand single grasp of one 303 can from case. Reach 18"	.56
MP65	One hand simo grasp of two 303 cans from case. Reach 18"	.84
MP66	Two hand transfer grasp of one 303 can from left hand. Reach 18"	.83
MP67	Two hand single grasp of one 303 can (with 2 faced label) per hand from case. Reach 18"	.63
MP68	Two hand single grasp of one 303 can per hand from case. Reach 12"	.71
MP69	Two hand single grasp of one 303 can per hand from case. Reach 18"	.47
MP70	Two hand single grasp of one 303 can per hand from case. Reach 24"	.49
MP71	Two hand single grasp of one 303 can per hand from case. Side reach 24"	.75
MP72	Two hand single grasp of one 303 can per hand from case. Reach 36"	.55
MP73	Two hand grasp of three 303 cans with both hands from case. Reach 18"	.65
MP74	Two hand simo grasp of two 303 cans per hand from case. Reach 18"	.65
MP75	Two hand single grasp of one 46 oz. can per hand from case. Reach 18"	.54

Evaluation of Skill

The following evaluations are based on matched pairs and matched series.

One Hand Versus Two Hand: These data present a comparison of one hand versus two hand work in terms of skill requirements.

		CND Grasp
MP58	One hand (single grasp - no orient)	.52
MP60	Two hand (single grasp - no orient)	.54
MP64	One hand (single grasp - orient)	.56
MP69	Two hand (single grasp - orient)	.47
MP65	One hand (simo grasp - orient)	.84
MP74	Two hand (simo grasp - orient)	.65

The data is incomprehensible concerning this factor. It indicates less skill for two hand grasps, which does not seem reasonable.

Grasp Types Used in Stocking Shelves with Cans - Labels Not Oriented:

The single grasp refers to a simple grasp of one can. The simo grasp refers to the simultaneous grasping of two cans in the same hand.

		CND Grasp
MP60	Single grasp	.54
MP61	Simo grasp	.63

The data shows a higher skill content for the simo grasp, which is to be expected.

Grasps Used in Stocking Shelves - Labels Oriented to Face Customers:
The transfer grasp refers to a single grasp of one can from the other hand. The single grasp refers to a simple grasp of one can in a hand. The grasp of three with both hands refers to a grasp of one in each hand plus another sandwiched between. The simo grasp refers to the simultaneous grasping of two cans in the same hand.

		CND Grasp
MP66	Transfer grasp	.83
MP64	Single grasp	.56
MP65	Simo grasp	.84

		CND Grasp
MP69	Single grasp	.47
MP73	Grasp of three with both hands	.65
MP74	Simo grasp	.65

The ranking of single, grasp three with both hands, and simo is as one would expect. The transfer grasp shows a high proportion of skill but this proportion refers to a very short performance time; thus, the skill content of transfer grasp is very small.

No Orienting Versus Orienting: Orienting refers to the turning of labels to a position facing toward the customer, that is, facing outward on the shelf.

		CND Grasp
MP58	No orient (single grasp)	.52
MP64	Orient (single grasp)	.56
MP62	No orient (single grasp)	.46
MP75	Orient (single grasp)	.54
MP61	No orient (simo grasp)	.63
MP74	Orient (simo grasp)	.65
MP60	No orient (single grasp)	.54
MP69	Orient (single grasp)	.47

Most of the time the data indicates more skill for orienting. Orienting occurs mainly during move and position but does leak over into grasp to some extent.

Front Reach Versus Side Reach: Shelves can be stocked from a position facing the shelf or from a position parallel to the shelf.

		CND Grasp
MP70	Front	.49
MP71	Side	.75

The data shows that more skill is required for grasps which follow side reaches.

303 Versus 46 Ounce Can: The 303 can is only about one quarter the size of the 46 ounce can.

		CND Grasp
MP62	46 ounce can (no orient)	.46
MP60	303 can (no orient)	.54
MP75	46 ounce can (orient)	.54
MP69	303 can (orient)	.47

When there was no orienting, the 46 ounce can required less skill in grasps, perhaps because of the larger spaces for the fingers to slip into in grasping. When orienting was done, the relation was reversed. This phenomenon is probably due to a greater part of orienting being done during grasps of the big cans than was the case with the smaller cans. This is reasonable since manipulating the large can after grasping is certainly more difficult than manipulating the small can after grasping. This would tend to cause some orienting to be done during grasp when handling 46 ounce cans. In other words, the cans were picked up in more nearly their properly oriented position.

The Distance Factor: This series is matched in all characteristics except distance.

		CND Grasp
MP68	12 inches	.71
MP69	18 inches	.47
MP70	24 inches	.49

The shortest distance definitely required more skill for grasps. This is probably due to the fact that the shorter reach did not allow sufficient time for eye requirements. Eyes were used to guide the hands to the proper cans and, to some extent, for locating the labels prior to orienting. If the reach were too short, some of the eye requirements must be added to grasp.

Summary

The data does not indicate clearly whether one or two hand work requires more skill.

The grasps in order of skill content are (1) single, (2) grasp three with both hands, and (3) simo grasp. The transfer grasp is high in skill proportion but this proportion refers to a very short performance time; thus, the skill content of transfer grasp is rather small.

Orienting requires more skill than no orienting.

Grasps following side reaches require more skill. Grasps of the 46 ounce can required less skill than grasps of the 303 can when there was no orienting but more when orienting was required.

The grasp following the shortest reach required the most skill, perhaps because the short reach did not give enough time for eye requirements to be completed before the termination of the reach.

Glass Jars

Although glass jars are fragile in a degree, this was not a very important factor. Data is very similar to data for can handling.

Inventory of Data

Stocking Shelves with Jars - Labels Not Oriented:

		CND Grasp
MP76	Two hand single grasp of one pint jar per hand from case. Reach 18"	.50
MP79	Two hand single grasp of one quart jar per hand from case. Reach 18"	.37

Stocking Shelves with Jars - Labels Oriented to Face Customers:

		CND Grasp
MP82	Two hand single grasp of one pint jar per hand from case. Reach 18"	.46

Evaluation of Skill

In the above data, orienting is the principle skill factor.

No Orienting Versus Orienting: Orienting refers to the turning of the jar labels so that they face outward from the shelf.

		CND Grasp
MP76	No orienting	.50
MP82	Orienting	.46

Orienting occurs mainly during the move and position but sometimes leaks over into grasp also. Apparently there was no orienting in the grasps in this instance because the pair with orienting showed even less skill than the one without orienting. The difference between these data is not believed to be significant.

The Size Factor: One pint and one quart jars were used. This is not a skill factor.

		CND Grasp
MP76	One pint	.50
MP79	One quart	.37

The larger jar required less skill to grasp. There does not appear to be a reasonable explanation for this because the portion of the jar grasped was the same size and shape in both cases.

Summary

Orienting had no significant effect on grasps.

The data shows less skill for the quart size but there appears to be no reasonable explanation why this should be true.

Glass Bottles

Although the bottles were fragile in some degree, this did not appear to affect the skill requirements.

Inventory of Data

Stocking Shelves with Bottles - Labels Not Oriented:

		CND Grasp
MP83	Two hand single grasp of one seven ounce bottle per hand from case. Reach 18"	.41
MP86	Two hand single grasp of one quart milk bottle per hand from case. Reach 18"	.27

Stocking Shelves with Bottles - Labels Oriented to Face Customers:

MP89	Two hand single grasp of one seven ounce bottle per hand from case. Reach 18"	.34

Evaluation of Skill

The principal skill factor represented in the above data is orienting.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward on the shelf.

		CND Grasp
MP83	No orienting	.41
MP89	Orienting	.34

Orienting occurs mainly during the move and position portion of the cycle, but sometimes leaks over into grasp to some extent. Apparently there was no orienting during the grasps of bottles since the data actually shows less skill for grasps which occurred in cycles where orienting was done. The difference between these data is not believed to be significant.

The Size Factor: Seven ounce soft drink bottles and quart milk bottles were used.

		CND Grasp
MP83	Seven ounce bottle	.41
MP86	Quart milk bottle	.27

The quart milk bottle may require less skill in grasping than the smaller seven ounce bottle. The shape of the quart milk bottle is better for grasping and there is more finger room between bottles. If there is a difference, it must be of negligible size.

Summary

Orienting had no significant effect on grasps.

The quart milk bottle required less skill in grasps than the seven ounce bottle, probably because it is shaped better for grasping.

Bags

The data in this section was taken from the handling of one and two pound paper bags and 25 pound burlap bags.

Inventory of Data

Stocking Shelves with Bags - Labels Not Oriented:

		CND Grasp
MP90	Two hand single grasp of a one pound bag per hand from case. Reach 18"	.42
MP93	Two hand single grasp of a two pound bag per hand from case. Reach 18"	.33

Stocking Shelves with Bags - Labels Oriented to Face Customers:

MP96	Two hand single grasp of a one pound bag per hand from case. Reach 18"	.62

Moving Large Bags From Stack to Conveyor:

		CND Grasp
MP97	Grasp one 25 pound bag with both hands from stack. Reach 24"	.35

Evaluation of Skill

Orienting is the chief skill factor in the above data.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward on the shelf.

		CND Grasp
MP90	No orienting	.42
MP96	Orienting	.62

Orienting occurs mainly during the move and position portion of the cycle but sometimes leaks over into the grasp. Apparently some orienting was accomplished during grasps in this instance since grasps which occurred in cycles where orienting was required had a considerably higher skill content.

The Weight Factor: One and two pound paper bags were used.

		CND Grasp
MP90	One pound	.42
MP93	Two pound	.33

Grasps of the two pound bags required less skill probably because the larger size made positioning the fingers for grasping somewhat easier.

Summary

Orienting added to the skill requirements of grasp in this case.

The larger bags required less skill to grasp than the smaller.

Boxes

The data in this section was taken from the handling of boxes of the following weights: 1/2 pound, 1 pound, 2 1/2 pound, 5 pound, 10 pound, 25 pound, and 50 pound.

Inventory of Data

Stocking Shelves with Boxes - Labels Not Oriented:

		CND Grasp
MP98	Two hand single grasp of one 1/2 pound box per hand from case. Reach 18"	.29
MP101	Two hand single grasp of one 1 pound box per hand from case. Reach 18"	.47
MP104	Two hand single grasp of one 2 1/2 pound box per hand from case. Reach 18"	.44
MP107	Two hand single grasp of one 5 pound box per hand from case. Reach 18"	.47

Stocking Shelves with Boxes - Labels Oriented to Face Customers:

MP110	Two hand single grasp of one 1/2 pound box per hand from case. Reach 18"	.58
MP111	Two hand single grasp of one 1 pound box per hand from case. Reach 18"	.45
MP112	Two hand single grasp of one 2 1/2 pound box per hand from case. Reach 18"	.61
MP113	Two hand single grasp of one 5 pound box per hand from case. Reach 18"	.43

Moving Boxes from Stack to Conveyor:

MP114	Grasp one 10 pound box with both hands from stack. Reach 18"	.49
MP115	Grasp one 10 pound box with both hands from stack. Reach 24"	.58
MP116	Grasp one 25 pound box with both hands from stack. Reach 24"	.42

		CND Grasp
MP117	Grasp one 25 pound box with both hands from stack. Reach 36"	.39
MP118	Grasp one 25 pound box with both hands from stack. Reach 48"	.22
MP119	Grasp one 50 pound box with both hands from stack. Reach 24"	.48

Evaluation of Skill

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward from the shelf.

		CND Grasp
MP98	No orient	.29
MP110	Orient	.58
MP101	No orient	.47
MP111	Orient	.45
MP104	No orient	.44
MP112	Orient	.61
MP107	No orient	.47
MP113	Orient	.43

Orienting occurs mainly during the move and position portion of the cycle but sometimes leaks over into the grasp. In the above data orient appears to affect grasp in half the pairs and not in the other half.

The Weight Factor in Stocking Shelves: Within these two series the only factor which varied was weight.

		CND Grasp
MP98	1/2 pound (no orient)	.29
MP101	1 pound (no orient)	.47
MP104	2 1/2 pound (no orient)	.44
MP107	5 pound (no orient)	.47
MP110	1/2 pound (orient)	.58
MP111	1 pound (orient)	.45
MP112	2 1/2 pound (orient)	.61
MP113	5 pound (orient)	.43

There appears to be no definite relation between weight and skill content.

The Weight Factor in Moving Boxes from Stock to Conveyor: The only factor in this series which varied was weight.

		CND Grasp
MP115	10 pound	.58
MP116	25 pound	.42
MP119	50 pound	.48

There appears to be no definite relation between weight and skill content.

The Distance Factor in Moving Boxes to Conveyor: Within each of these series, distance was the only factor which varied.

		CND Grasp
MP114	18 inches (10 pound)	.49
MP115	24 inches (10 pound)	.58

		CND Grasp
MP116	24 inches (25 pound)	.42
MP117	36 inches (25 pound)	.39
MP118	48 inches (25 pound)	.22

For the lighter weight boxes, the skill of grasp increased as distance increased. For the heavier boxes, the skill of grasps decreased as distances increased.

Summary

Orienting showed no consistent relation to the skill content of grasps.

There appeared to be no definite relation between weight and the skill content of grasps.

For the 10 pound boxes, the skill in grasps increased as distance increased. For the 25 pound boxes, the skill in grasps decreased as distance increased.

CHAPTER IV

BASIC MOTION: EVALUATION OF SKILL IN POSITION-RELEASES

It is quite apparent that one cannot completely separate the motion classes of orient, position, and release by film analyses. Consequently, releases were measured independently only when there was no orienting or positioning. When either or both of these occurred, it was measured along with release as a single unit. The following skill evaluations apply to this combined unit.

Even in the combined form there was considerable inaccuracy involved in the measurement of the unit due to the overlapping nature of the motions. Orienting may actually begin in the grasp, continue throughout the move, and be finished during the positioning of the object. Positioning is almost as bad. The occurrence of a precise positioning may elicit one or the other of two extremes or any degree between them. The person may move precisely to the destination and release the object. On the other hand, he may move with some abandon to the vicinity of the destination and then do a positioning which is virtually independent of the move.

The overlapping nature of these motions makes discrepancies unavoidable in film analysis. These discrepancies cause the correlation measure, which is based on motion times, to break down somewhat in accuracy. In actual practice it was determined that correlations of reach with total cycle data give a more reliable answer, even for the motions of position-release.

The actual measure used is the coefficient of non-determination $(1 - r^2)$.

Round or Oblong Fruits and Vegetables

The data in this section pertains to the handling of fruits and vegetables which are roughly round or oblong in shape. Specifically the data was taken from the handling of apples, oranges, potatoes, lemons, grapefruit and cabbage. These commodities were classified according to weight.

The data obtained by holding the motion pattern and weight constant while varying the commodity shows but little change from one commodity to another. This indicates that the data can be used satisfactorily for commodities which are not included but which fit the same shape, size and weight specifications.

Inventory of Data

Releases Which Occur in Jumble Packing Fruits and Vegetables, 1/4 - 3/4 Pounds in Weight:

		CND* Release
MP2	One hand single release of two apples	.44
MP3	One hand single release of one apple	.45
MP5	Two hand single release of one apple per hand	.41
MP6	Two hand simo release of two apples per hand	.58
MP7	Two hand simo release of two apples per hand	.55
MP8	Two hand simo release of two potatoes per hand	.61
MP9	Two hand simo release of two lemons per hand	.63
MP10	Two hand simo release of two apples per hand	.76
MP11	Two hand simo release of two oranges per hand	.58
MP12	Two hand simo release of two apples per hand	.60
MP13	Two hand simo release of two and one half apples per hand	.53
MP14	Two hand simo release of three apples per hand	.69

Position Releases Which Occur in Layer Packing Fruits and Vegetables, 1/4 - 3/4 Pounds in Weight:

		CND Pos-rel**
MP15	One hand single position-release of one apple (following single grasp from flat surface)	.47
MP16	One hand consecutive position-release of two apples per hand (following simo grasp from flat surface)	.57
MP17	Two hand single position-release of one apple per hand (following single grasp from flat surface)	.57

* Abbreviation for Coefficient of non-determination
** Abbreviation for position-release

		CND Pos-rel
MP18	Two hand consecutive position-release of two apples per hand (following simo grasp from flat surface)	.72
MP19	Two hand consecutive position-release of two apples per hand (following simo grasp from flat surface)	.68
MP20	Two hand consecutive position-release of two apples per hand (following simo grasp from flat surface)	.66
MP21	Two hand consecutive position-release of two apples per hand (following consecutive grasp from flat surface)	.68
MP22	Two hand consecutive position-release of two apples per hand (following simo grasp from a box)	.97
MP23	Two hand consecutive position-release of two apples per hand (following consecutive grasp from box)	.84

Releases Used in Stacking Fruit or Vegetable Display Bins, Weights Approximately 1, 2 and 3 Pounds:

		CND Release
MP24	Two hand single release of one 1-pound grapefruit per hand in bin. Move 18"	.56
MP27	Two hand single release of one 2-pound cabbage per hand in bin. Move 18"	.29
MP30	Two hand release of one 3-pound cabbage with both hands. Move 18"	.33

Evaluation of Skill

One Hand Versus Two Hand: Occasionally one will observe a worker employing only one hand in the performance of his work.

		CND Release
MP2	One Hand (jumble pack)	.44
MP5	Two Hand (jumble pack)	.41

		CND Pos-rel
MP15	One Hand (layer pack)	.47
MP17	Two Hand (layer pack)	.57
MP16	One Hand (layer pack)	.57
MP19	Two Hand (layer pack)	.68

In jumble packing it made little difference whether one used one hand or two hands in working, the skill content was not greatly affected. In layer packing, there is a definite indication that more skill is required for two hand work.

Release Types Used in Jumble Packing: The single release refers to a simple release of one object with no apparent positioning. The simo release refers to the simultaneous release of two objects with no apparent positioning. The simo two-and-one-half release refers to the simultaneous release of five objects from both hands following a pincer grasp. There is no apparent positioning for this release. The simo three release refers to the simultaneous releasing of three apples with no apparent positioning.

		CND Release
MP5	Single release	.41
MP10	Simo release	.76
MP13	Simo two-and-one-half releases	.53
MP14	Simo three releases	.69

The data indicates substantially more skill is required for multiple releases.

Position-Releases Used in Layer Packing: The single position-release refers to orienting a single apple, positioning it in the layer, and releasing it. The consecutive position-release starts with two apples in the hand. The first one is oriented, positioned, and released; then the second one is brought from the palm into the fingers, oriented, positioned, and released.

		CND Pos-rel
MP15	Single position-release	.47
MP16	Consecutive position-release	.57

		CND Pos-rel
MP17	Single position-release	.57
MP19	Consecutive position-release	.68

More skill is indicated for the consecutive position-release.

Following Grasp of Fruit From Flat Surface Versus Following Grasp From Filled Bin or Box: Grasps from a flat surface are encountered in taking fruit from a belt or from the bottom of a bin. Grasps of fruit from a filled bin or box differ in that the fruit is jumbled in depth.

		CND Pos-rel
MP21	Following a grasp from a flat surface	.68
MP23	Following grasp from a filled bin or box	.84
MP19	Following a grasp from flat surface	.68
MP22	Following a grasp from a filled bin or box	.97

This data shows considerably more skill is required to perform position-releases if they follow grasps made from a filled bin or box.

Following Consecutive Grasp Versus Following A Simo Grasp: There was no opportunity to orient fruit during simo grasps, but considerable orienting could be accomplished during consecutive grasps.

		CND Pos-rel
MP21	Following consecutive grasp (flat surface)	.68
MP19	Following simo grasp (flat surface)	.68
MP23	Following consecutive grasp (box)	.84
MP22	Following simo grasp (box)	.97

Some orienting apparently could be completed during the move when the grasps were made from a flat surface, regardless of the type of grasp. When grasps were made from a filled box, more skill was required for the position-releases which followed. Even more skill was required when position-releases followed simo grasps from a filled box.

Top of Crate Versus Bottom of Crate: A sharp change of direction occurs during a move when packing in the bottom of a crate but not while packing the top layers.

		CND Pos-rel
MP19	Top of crate	.68
MP20	Bottom of crate	.66

The change of direction applies to the move but apparently does not apply in any significant degree to the position-release.

The Weight Factor: The same motion pattern was used in handling one-pound grapefruit and two-pound cabbage.

		CND Release
MP24	One-pound grapefruit	.56
MP27	Two-pound cabbage	.29

The data shows less skill is required for releases of the heavier cabbage. It is doubtful that there is much difference between them. These releases are of very short duration and slight errors in measuring affect the skill measure a great deal.

The Distance Factor: Only distance varied in this series.

		CND Release
MP6	16 inches	.58
MP10	24 inches	.76
MP12	32 inches	.60

This data shows very little relation between distance and the skill content of releases.

Summary

In jumble packing it made little difference whether one used one hand or two hands in working; the skill content was not greatly affected.

In layer packing, there is a definite indication that more skill is required for two hand work.

In jumble packing, more skill is required for multiple releases.

In layer packing, the consecutive position-release requires substantially more skill than the single position-release.

This data shows that considerably more skill is required to perform position-releases which follow grasps made from a filled bin or box than is required if they follow grasps from a flat surface.

This data shows that considerably more skill is required to perform position-releases which follow simo grasps than is required if they follow consecutive grasps, if the grasps were made from a filled box. The type of grasp appeared to have no effect on position-release when grasps were made from a flat surface.

The change of direction applies to the move but apparently does not apply in any significant degree to position-release.

This data shows no relation between distance and the skill content of releases.

Bunch Vegetables

There is no factor represented in these motion patterns which is primarily a skill factor.

Inventory of Data

		CND Release
MP33	Two hand single release of one pound artificial bunch vegetables per hand on display rack. Move 18"	.89
MP36	Two hand single release of a two pound celery per hand on display rack. Move 18"	.39

Evaluation of Skill

There were no matched pairs for evaluation of skill in the handling of bunch vegetables.

Eggs

The additional factor of fragility is introduced in egg handling. It is quite apparent in observing the work that fragility is of considerable importance.

Inventory of Data

Position-Releases Which Occur In Loading Egg Grader:

		CND Pos-rel
MP39	One hand single position-release of one egg on grader track. Move 12"	.66
MP40	One hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Move 12"	.75
MP41	One hand consecutive position-release of two eggs per hand on grader track (following consecutive grasp). Move 12"	.33
MP42	Two hand single position-release of one egg per hand on grader track. Move 12"	.78
MP43	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Move 12"	.69
MP44	Two hand consecutive position-release of two eggs per hand on grader track (following consecutive grasp). Move 12"	.56
MP45	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Move 16"	.53
MP46	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Side move 12"	.37
MP47	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Move 24"	.59

Position-Releases Which Occur in Packing Eggs:

		CND Pos-rel
MP48	One hand single position-release of one egg. Move 12"	.98
MP49	Two hand single position-release of one egg per hand in case. Move 12"	.67
MP50	Two hand consecutive position-release of two eggs per hand in case (following simo grasp). Move 12"	.97
MP51	Two hand consecutive position-release of two eggs per hand in bottom of case (following consecutive grasp). Move 12"	.66
MP52	Two hand consecutive position-release of two eggs per hand in bottom of case (following consecutive grasp). Move 12"	.44
MP53	Two hand consecutive position-release of three eggs per hand in case (following simo three grasp). Move 12"	.82
MP54	Two hand consecutive position-release of three eggs per hand in case (following two plus one grasp). Move 12"	.88

Weighing Eggs on a Single Egg Scale - One Hand Operation Only:

MP55	One hand single transfer-release of an egg into other hand. Move 12"	.70
MP56	One hand single position-release of an egg on cup of egg scales. Move 12"	.58

Evaluation of Skill

The following evaluations are based on matched pairs and matched series.

One Hand Versus Two Hand Work: The following data present a measurement of the effect of one hand work compared to two hand work in terms of skill requirements.

		CND Pos-rel
MP39	One hand (grading)	.66
MP42	Two hand (grading)	.78
MP41	One hand (grading)	.33
MP44	Two hand (grading)	.56
MP40	One hand (grading)	.75
MP43	Two hand (grading)	.69
MP48	One hand (packing)	.98
MP49	Two hand (packing)	.67

The data does not show clearly whether one or two hand work requires the most skill.

Types of Position-Releases Used in Grading: The single position-release refers to the positioning of one egg on the grader track so that the long axis of the egg lays across the two sides of the track, and then releasing it. The consecutive position-release refers to a single position-release followed by a regrasping of another egg from the palm to the fingers, and a position-release of the second egg. The difficulty of performing the consecutive position-release varies depending on whether it follows a consecutive or simo grasp. Both versions are shown.

		CND Pos-rel
MP39	Single position-release	.66
MP41	Consecutive position-release (after consecutive grasp)	.33
MP40	Consecutive position-release (after simo grasp)	.75
MP42	Single position-release	.78
MP44	Consecutive position-release (after consecutive grasp)	.56
MP43	Consecutive position-release (after simo grasp)	.69

The single position-release shows a relatively high proportion of skill but this proportion refers to a very short performance time; thus, the skill content of a single release is quite small. The skill required by the consecutive position-release was much greater when the position-release followed a simo grasp. This is to be expected since the eggs can be oriented very well during a consecutive grasp, but not during a simo grasp.

Types of Position Release Used in Packing: The single position-release refers to the positioning of a single egg over a cell in an egg filler with the pointed end of the egg pointing downward and releasing it. The consecutive two position-release refers to one single position-release followed by another for a second egg from the same hand. The consecutive three position-release refers to three single position-releases performed consecutively with three eggs all from the same hand. It follows a simo three or two-plus-one grasp.

		CND Pos-rel
MP49	Single position-release	.67
MP51	Consecutive two position-release (after consecutive grasp)	.66
MP50	Consecutive two position-release (after simo grasp)	.97
MP54	Consecutive three position-release (after two-plus-one grasp)	.88
MP53	Consecutive three position-release (after simo three grasp)	.82

The least skill was required by the single position-release and the consecutive position-release which followed a consecutive grasp. The other three consecutive position-releases all followed grasps which are wholly or partly simo in nature. The simo grasps do not permit orienting the eggs during the grasp, consequently the position-releases which follow them will include some orienting and consequently more skill.

Change of Direction in Move: When eggs were packed in the bottom of the case, a change of direction occurred in the move which did not occur when packing in the top of the case.

		CND Pos-rel
MP51	No change of direction (top of case)	.66
MP52	Change of direction (bottom of case)	.44

There is an obvious discrepancy in this data since the position-releases in this pair were alike. It may be that the change of direction introduced some skill into the reach. On the other hand, the change of direction may have slowed down the move sufficiently to enable the position-release to be performed with greater ease.

Front Versus Side Move: A work place can be set up so that moves are to the front or to the side.

		CND Pos-rel
MP43	Front move	.69
MP46	Side move	.37

The data shows a lower skill content for position-releases which follow a side move. There is no apparent reason for this relationship.

The Distance Factor: This series varied only in distance.

		CND Pos-rel
MP43	12 inches	.69
MP45	16 inches	.53
MP47	24 inches	.59

This data shows no relation between the distance of move and the skill content of the position-release.

Summary

The data does not show clearly whether one or two hand work requires the most skill.

The single position-releases show a relatively high proportion of skill but this proportion refers to a very short performance time; thus the skill content of single position-releases is quite low. Consecutive position-releases which follow consecutive grasps are low in skill. Consecutive position-releases which follow simo grasps require considerably more skill. Considerable orienting can be accomplished during a consecutive grasp but not during a simo grasp. Consequently, any grasp which is wholly or partially simo in nature will add to the skill content of the subsequent position-release.

This data shows no relation between the skill content of position-release and the distance of move.

Cans

In addition to the different types of positioning, the handling of cans introduces a type of orienting which is most certainly a skill factor. Cans are usually oriented on the shelf so that the labels face outward.

Inventory of Data

Stocking Shelves with Cans - Labels Not Oriented:

		CND Pos-rel
MP58	One hand single position-release of one 303 can on shelf. Move 18"	.59
MP60	Two hand single position-release of one 303 can per hand on shelf. Move 18"	.56
MP61	Two hand simo position-release of two 303 cans per hand on shelf. Move 18"	.77
MP62	Two hand single position-release of one 46 ounce can per hand on shelf. Move 18"	.48

Stocking Shelves with Cans - Labels Oriented to Face Customers:

MP64	One hand single position-release of a 303 can on shelf. Move 18"	.74
MP65	One hand consecutive position-release of two 303 cans on shelf. Move 18"	.60
MP66	Two hand single position-release of one 303 can on shelf (after transfer grasp from other hand). Move 18"	.98
MP67	Two hand single position-release of a 303 can (with 2 faced label) per hand on shelf. Move 18"	.47
MP68	Two hand single position-release of one 303 can per hand on shelf. Move 12"	.66
MP69	Two hand single position-release of one 303 can per hand on shelf. Move 18"	.57
MP70	Two hand single position-release of one 303 can per hand on shelf. Move 24"	.62

		CND Pos-rel
MP71	Two hand single position-release of one 303 can per hand on shelf. Side move 24"	.65
MP72	Two hand single position-release of one 303 can per hand on shelf. Move 36"	.68
MP73	Two hand position-release of three 303 cans with both hands on shelf. Move 18"	.68
MP74	Two hand consecutive position-release of two 303 cans per hand on shelf. Move 18"	.66
MP75	Two hand single position-release of one 46 ounce can per hand on shelf. Move 18"	.39

Evaluation of Skill

The following evaluations are based on matched pairs and matched series.

One Hand Versus Two Hand: Frequently one observes a person working with only one hand. These data show a measure of the effect of number of hands employed on skill content of handling cans.

		CND Pos-rel
MP58	One hand (single position-release, no orient)	.59
MP60	Two hand (single position-release, no orient)	.56
MP64	One hand (single position-release, orient)	.74
MP69	Two hand (single position-release, orient)	.57
MP65	One hand (simo position-release, orient)	.60
MP74	Two hand (simo position-release, orient)	.66

This data gives no clear indication that one hand work requires any more skill than two hand work.

Position-Releases Used to Stock Shelves with Cans - Labels Not Oriented: The single position-release refers to the positioning of a can in its place on the shelf and the releasing of the can. The simo position-release refers to positioning two cans per hand simultaneously on the shelf and releasing them.

		CND Pos-rel
MP60	Single position-release	.56
MP61	Simo position-release	.77

The data indicates a higher skill is needed for the simo position-release.

Position-Release Used to Stock Shelves with Cans - Labels Oriented to Face Customers: The single position-release after transfer grasp refers to the orienting of one can with the right hand, and the positioning and release of that can. The single position-release is the same except that the grasp is made from the case. The position-release three with both hands refers to a single position-release of one can per hand followed by a position-release of the third can usually with the right hand. The consecutive position-release refers to a single position-release followed by a position-release of a second can from the same hand.

		CND Pos-rel
MP66	Single position-release (after transfer grasp)	.98
MP64	Singleposition-release (after single grasp)	.74
MP65	Consecutive position-release	.60
MP69	Single position-release	.57
MP73	Position-release three with both hands	.68
MP74	Consecutive position-release	.66

The single position-releases show a rather high proportion of skill but this proportion refers to a very short performance time; thus, the skill content of single position releases is rather low. The skill proportion of the consecutive position-releases seem low but this proportion refers to long performance times, making the skill content of the consecutive position-releases relatively great.

No Orienting Versus Orienting: Orienting refers to the turning of labels to a position facing toward the customer; that is, facing outward on the shelf.

		CND Pos-rel
MP58	No orienting (one hand)	.59
MP64	Orienting (one hand)	.74
MP62	No orienting (two hand)	.48
MP75	Orienting (two hand)	.39
MP60	No orienting (two hand)	.56
MP69	Orienting (two hand)	.57
MP61	No orienting (two hand)	.77
MP74	Orienting (two hand)	.66

This data does not indicate clearly whether orienting or no orienting requires more skill. Orienting is unmistakably a skill factor but the actual performance of this motion can be shifted quite readily from one part of the cycle to another. This accounts for the inconsistency of the effect of orienting on position-releases.

Front Move Versus Side Move: Shelves can be stocked from a position facing the shelf or from a position parallel to the shelf.

		CND Pos-rel
MP70	Front	.62
MP71	Side	.65

There is very little difference shown between the skill content of position-releases which followed side moves and those which followed front moves.

303 Can Versus 46 Ounce Can: The 303 can is only about one quarter the size of the 46 ounce can.

		CND Pos-rel
MP60	303 can (no orient)	.56
MP62	46 ounce can (no orient)	.48
MP69	303 can (orient)	.57
MP75	46 ounce can (orient)	.39

This measure shows a lower skill content of position-release for 46 ounce cans. This is undoubtedly caused by the larger base of the 46 ounce can which makes them easier to position.

The Distance Factor: This series is matched in all characteristics except distance.

		CND Pos-rel
MP68	12 inches (orient)	.66
MP69	18 inches (orient)	.57
MP70	24 inches (orient)	.62

The 12 inch distance shows higher skill requirement perhaps because there is insufficient time during the move for orienting. The 24 inch distance shows higher skill requirements perhaps because it is more difficult to control orienting and positioning at arms length.

Summary

This data gives no clear indication concerning the effect of one hand and two hand work on skill content of position-release.

The simo position-release requires more skill than the single when cans are not oriented. When cans are oriented, the single position-releases show a rather high proportion of skill but this proportion refers to a very short performance time; thus the skill content of single position-releases is rather low. The skill proportion of the consecutive position-releases seem low but these proportions refer to long performance times, making the skill content of the consecutive position-releases relatively great.

This data does not indicate any definite effect of orienting on skill content. This inconsistency is perhaps due to the fact that

orienting can be done at almost any phase of the cycle. It is not necessarily a part of position-release alone.

The data shows a lower skill for 46 ounce cans than for 303 cans. The larger base of the 46 ounce cans undoubtedly makes them easier to position.

Both the short and the long distance showed a higher skill content than the middle distance. The short distance does not allow sufficient time for orienting during the move. Control of orienting and positioning is more difficult at arms length.

Glass Jars

Although glass jars are fragile in a degree, this was not a very important factor. Data is very similar to data for can handling.

Inventory of Data

Stocking Shelves with Jars - Labels Not Oriented:

		CND Pos-rel
MP76	Two hand single position-release of one pint jar per hand on shelf. Move 18"	.25
MP79	Two hand single position-release of one quart jar per hand on shelf. Move 18"	.38

Stocking Shelves with Jars - Labels Oriented to Face Customers:

MP82	Two hand single position-release of one pint jar per hand on shelf. Move 18"	.59

Evaluation of Skill

The principal skill factor in the above data is orienting.

No Orienting Versus Orienting: Orienting refers to the turning of jar labels so that they face outward on the shelf.

		CND Pos-rel
MP76	No orienting	.25
MP82	Orienting	.59

Orienting clearly requires more skill.

The Size Factor: One pint and one quart jars were used.

		CND Pos-rel
MP76	Pint jar	.25
MP79	Quart jar	.38

The quart jars require more skill. The heavier weight increases the momentum and makes the position-release more difficult to control.

Summary

Orienting clearly requires more skill than no orienting.

Quart jars clearly require more skill than pint jars.

Glass Bottles

Although the bottles were fragile in a degree, this appeared to have little if any effect on skill requirements.

Inventory of Data

Stocking Shelves with Bottles - Labels Not Oriented:

		CND Pos-rel
MP83	Two hand single position-release of one seven ounce bottle on shelf. Move 18"	.36
MP86	Two hand single position-release of one quart milk bottle on shelf. Move 18"	.41

Stocking Shelves with Bottles - Labels Oriented to Face Customers:

		CND Pos-rel
MP89	Two hand single position-release of one seven ounce bottle per hand on shelf. Move 18"	.83

Evaluation of Skill

The principal skill factor represented in the above data is orienting.

No Orienting Versus Orienting: Orienting refers to the turning of bottle labels so that they face outward on the shelf.

		CND Pos-rel
MP83	No orienting	.36
MP89	Orienting	.83

Orienting clearly requires more skill.

The Size Factor: Seven ounce soft drink bottles and quart milk bottles were used.

		CND Pos-rel
MP83	Seven ounce bottle	.36
MP86	Quart milk bottle	.41

The quart milk bottle requires very slightly more skill. The heavier weight increases momentum and makes position-releases more difficult to control.

Summary

Orienting clearly requires more skill than no orienting in position-release.

Quart milk bottles require slightly more skill than the seven ounce bottles in position-release.

Bags

The data in this section was taken from the handling of one and two pound paper bags and 25 pound burlap bags.

Inventory of Data

Stocking Shelves with Bags - Labels Not Oriented:

		CND Pos-rel
MP90	Two hand single position-release of a one pound bag per hand on shelf. Move 18"	.59
MP93	Two hand single position-release of a two pound bag per hand on a shelf. Move 18"	.38

Stocking Shelves with Bags - Labels Oriented to Face Customers:

MP96	Two hand single position-release of a one pound bag per hand on shelf. Move 18"	.37

Moving Large Bags From the Stack to Conveyor:

MP97	Release one 25 pound bag with both hands on conveyor. Move 24"	.33

Evaluation of Skill

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward on the shelf.

		CND Pos-rel
MP90	No orienting	.59
MP96	Orienting	.37

The data shows less skill for position-release when labels were oriented. This apparent discrepancy is caused by the fact that orienting is done during move rather than during position-release in handling bags. The bags are not round and are, therefore, not convenient to turn during the positioning.

The Weight Factor: One pound and two pound paper bags were used.

		CND Pos-rel
MP90	One pound	.59
MP93	Two pound	.38

In this instance the weight difference is believed to be less important than the size of the base of these bags. The one pound bags had such a small base that they were obviously more difficult to position so that they would not topple over.

Summary

The data shows less skill in position-release when orienting was required. In this instance, the orienting occurred more in move than in position-release.

This data also shows that more skill is required in the position-release of the one pound bags. This is believed to be due to the difficulty of positioning the smaller bags so that they would not topple over when released.

Boxes

The data in this section was taken from the handling of boxes of the following weights: 1/2 pound, 1 pound, 2 1/2 pound, 5 pound, 10 pound, 25 pound, and 50 pound.

Inventory of Data

Stocking Shelves with Boxes - Labels Not Oriented:

		CND Pos-rel
MP98	Two hand single position-release of one 1/2 pound box per hand on shelf. Move 18"	.35
MP101	Two hand single position-release of one 1-pound box per hand on shelf. Move 18"	.58
MP104	Two hand single position-release of one 2 1/2 pound box per hand on shelf. Move 18"	.46

		CND Pos-rel
MP107	Two hand single position-release of one 5-pound box per hand on shelf. Move 18"	.54

Stocking Shelves with Boxes - Labels Oriented to Face Customers:

MP110	Two hand single position-release of one 1/2 pound box per hand on shelf. Move 18"	.71
MP111	Two hand single position-release of one 1-pound box per hand on shelf. Move 18"	.72
MP112	Two hand single position-release of one 2 1/2 pound box per hand on shelf. Move 18"	.73
MP113	Two hand single position-release of one 5-pound box per hand on shelf. Move 18"	.69

Moving Boxes from Stack to Conveyor:

		CND Release
MP114	Release one 10-pound box with both hands on conveyor. Move 18"	.44
MP115	Release one 10-pound box with both hands on conveyor. Move 24"	.45
MP116	Release one 25-pound box with both hands on conveyor. Move 24"	.43
MP117	Release one 24-pound box with both hands on conveyor. Move 36"	.50
MP118	Release one 25-pound box with both hands on conveyor. Move 48"	.38
MP119	Release one 50-pound box with both hands on conveyor. Move 24"	.44

Evaluation of Skill

Orienting is the principal skill factor in the above data.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward on the shelf.

		CND Pos-rel
MP98	No orient (½ pound)	.35
MP110	Orient (½ pound)	.71
MP101	No orient (1 pound)	.58
MP111	Orient (1 pound)	.72
MP104	No orient (2½ pound)	.46
MP112	Orient (2½ pound)	.73
MP107	No orient (5 pound)	.54
MP113	Orient (5 pound)	.69

Orienting requires substantially more skill than no orienting.

The Weight Factor in Stocking Shelves: Within each of the following series the only factor which varied was weight.

		CND Pos-rel
MP98	½ pound (no orient)	.35
MP101	1 pound (no orient)	.58
MP104	2½ pound (no orient)	.46
MP107	5 pound (no orient)	.54
MP110	½ pound (orient)	.71
MP111	1 pound (orient)	.72
MP112	2½ pound (orient)	.73
MP113	5 pound (orient)	.69

There appears to be very little, if any, relationship between weight and the skill content of position-release when stocking shelves.

The Weight Factor in Moving Boxes from Stack to Conveyor: The only factor which varied was weight.

		CND Release
MP115	10 pound	.45
MP116	25 pound	.43
MP119	50 pound	.44

There is no definite indication that weight affected the skill content of releases when moving boxes from stack to conveyor.

The Distance Factor in Moving Boxes from Stack to Conveyor: Within each of these series, distance was the only factor which varied.

		CND Release
MP114	18 inches (10 pound)	.44
MP115	24 inches (10 pound)	.45
MP116	24 inches (25 pound)	.43
MP117	36 inches (25 pound)	.50
MP118	48 inches (25 pound)	.38

The data does not indicate any definite relationship between distance and the skill content of releases.

Summary

Orienting requires substantially more skill than no orienting.

There appears to be no relationship between weight and the skill content of position-release whether one is stocking shelves or moving large boxes from the stack to conveyor.

In moving large boxes from stack to conveyor, no relationship can be detected between the distance moved and the skill content of releases.

CHAPTER V

BASIC MOTIONS: EVALUATIONS OF METHODS DIFFERENCES IN REACHES AND MOVES

Reach and move are travel motions. They are distinctly different in nature from the motion classes orient, position and release, which are manipulative. The ability to perform manipulative motions is considered to be skill. The travel motions of reach and move are readily controlled by voluntary decision or, in other words, they are governed by effort.

Although the correlation measurement of skill shows a definite tendency for the coefficient of non-determination of move to rise as the general skill content of the whole motion pattern rises, this relationship is not believed to be meaningful. In film analysis one can not entirely separate the move and the position-release. Consequently, there is some leakage of the effect of the skill content of position-release into the move data. This makes it appear that the move has a higher skill content than it really has. The same would be true of reach, very likely. However, reach was selected as the base motion and thereby became the measuring stick for other motions. One can note that there is some tendency for reach to take longer when the grasp is longer. Undoubtedly the same leakage exists between reach and grasp as exists between move and position-release.

Even with the difficulties of measuring the basic time data for motions accurately, the correlation measure shows move to be much lower in skill content than either grasp or position-release. The following data is cited to illustrate this point.

	Average coefficient of non-determination		
	Move	Grasp	Pos-rel
Jumble pack apples and other fruits of similar size, shape and weight.	.19	.39	.57
Layer pack apples.	.40	.76	.68

Even if some skill should be attributed to the travel motions of reach and move, it would be beyond the capacity of the known techniques to measure skill in such low proportions. It seems most likely that the skill content of the cycle is more appropriately assigned to the manipulative motions of grasp, orient, position and release.

While the connection between skill and the travel motions is not entirely clear, it is quite apparent that there are certain factors in the realm of method which affect them. These are measured in terms of performance time.

Method Changes Which Affect Reach

Method variations which affect reach per se are: (1) number of hands, (2) distance, and (3) whether or not there is a sharp change of direction in reach.

Roughly Round Fruits and Vegetables

One Hand Versus Two Hands: Some increase in performance time is expected when both hands are used.

		Reach Time
MP2	One hand (jumble pack)	17.7
MP5	Two hands (jumble pack)	22.5
MP15	One hand (layer pack)	17.1
MP17	Two hands (layer pack)	20.3
MP16	One hand (layer pack)	18.0
MP19	Two hands (layer pack)	22.5

The two hand reaches take longer.

No Change of Direction Versus Change of Direction: When a sharp change of direction occurs during a reach, it slows down the rate of travel. Such a change occurs during a reach when packing in the bottom of a crate but does not occur while packing the top layers.

		Reach Time
MP19	No change of direction	22.5
MP20	Change of direction	23.9

Change of direction adds some to performance time.

The Distance Factor: The only factor which varied in this series was distance.

		Reach Time
MP6	16 inch (apple)	20.8
MP10	24 inch (apple)	23.8
MP12	32 inch (apple)	25.6

Reach time increased as distance increased.

Eggs

One Hand Versus Two Hands: Some increase in performance time of reach is expected when both hands are used.

		Reach Time
MP39	One hand (grading)	16.4
MP42	Two hands (grading)	18.8
MP41	One hand (grading)	17.1
MP44	Two hands (grading)	18.3
MP40	One hand (grading)	16.8
MP43	Two hands (grading)	20.6
MP48	One hand (packing)	16.0
MP49	Two hands (packing)	19.0

In each case the two hand reach took longer.

No Change of Direction Versus Change of Direction: When eggs were packed in the bottom of the case, a change of direction occurred in the reach which did not occur when packing in the top of the case.

		Reach Time
MP51	No change of direction	19.2
MP52	Change of direction	21.4

Change of direction added some to reach performance time.

The Distance Factor: This series varied only in distance.

		Reach Time
MP43	12 inches	20.6
MP45	16 inches	22.1
MP47	24 inches	27.6

Reach time increased as distance increased.

Front Reach Versus Side Reach: A work place can be set up so that reaches are to the front or to the side.

		Reach Time
MP43	Front reach	20.6
MP46	Side reach	27.1

The side reach was considerably longer in performance time.

Cans

Front Reach Versus Side Reach: A work place can be set up so that reaches are to the front or to the side.

		Reach Time
MP70	Front reach	19.6
MP71	Side reach	22.3

The side reach took more time to perform.

One Hand Versus Two Hands: Some increase is expected in the performance time of reach when both hands are used.

		Reach Time
MP58	One hand (single grasp)	15.2
MP60	Two hands (single grasp)	17.2

		Reach Time
MP64	One hand (single grasp)	15.3
MP69	Two hands (single grasp)	17.3
MP65	One hand (simo grasp)	16.3
MP74	Two hands (simo grasp)	17.4

In each case the two hand reach took longer.

The Distance Factor: This series varied only in distance.

		Reach Time
MP68	12 inch (orient)	14.5
MP69	18 inch (orient)	17.3
MP70	24 inch (orient)	19.6

Reach time increased as distance increased.

Boxes

The Distance Factor: These two series varied only in distance.

		Reach Time
MP114	18 inch (10 pound)	19.2
MP115	24 inch (10 pound)	20.6
MP116	24 inch (25 pound)	22.1
MP117	36 inch (25 pound)	25.2
MP118	48 inch (25 pound)	29.1

Reach time increased as distance increased.

Summary

Reach time is greater when two hands are used than when only one one hand is used. Reach time increases as distance increases but at a much lower rate. A sharp change of direction during a reach increases performance time.

Method Changes Which Affect Move

Method variations which affect move per se are: (1) number of hands, (2) change of direction, (3) distance, and (4) weight.

Roughly Round Fruits and Vegetables

One Hand Versus Two Hand: Some increase in performance time is expected when both hands are used.

		Move Time
MP2	One hand (jumble pack)	18.2
MP5	Two hands (jumble pack)	22.9
MP15	One hand (layer pack)	18.4
MP17	Two hands (layer pack)	22.3
MP16	One hand (layer pack)	19.0
MP19	Two hands (layer pack)	27.8

In each case the two hand move took longer.

No Change of Direction Versus Change of Direction: When a sharp change of direction occurs during a move it slows down the rate. Such a change of direction occurs when packing in the bottom of a crate, but does not occur while packing the top layers.

		Move Time
MP19	No change of direction (top of crate)	27.8
MP20	Change of direction (bottom of crate)	34.0

Change of direction increased performance time.

The Weight Factor: The same motion pattern was used in handling one-pound grapefruit and two-pound cabbage.

		Move Time
MP24	One-pound grapefruit	23.8
MP27	Two-pound cabbage	26.0

The heavier cabbage required more time.

The Distance Factor: In this series, distance was the only factor which varied.

		Move Time
MP6	16 inches (apple)	21.1
MP10	24 inches (apple)	24.9
MP12	32 inches (apple)	27.4

Move time increased as distance increased.

Eggs

One Hand Versus Two Hand: Some increase in performance time is expected when two hand work is done.

		Move Time
MP39	One hand (grading)	18.8
MP42	Two hand (grading)	22.1
MP41	One hand (grading)	21.0
MP44	Two hands (grading)	24.2
MP40	One hand (grading)	21.8
MP43	Two hands (grading)	27.3
MP48	One hand (packing)	16.0
MP49	Two hands (packing)	19.2

In each case the two hand move required more time.

No Change of Direction Versus Change of Direction: When eggs are packed in the bottom of the case, a sharp change of direction occurs in the move which does not occur when packing in the top of the case.

		Move Time
MP51	No change of direction (top of case)	17.5
MP52	Change of direction (bottom of case)	25.2

The change of direction added substantially to move performance time.

Front Move Versus Side Move: A work place can be set up so that moves are to the front or to the side.

		Move Time
MP43	Front move	27.3
MP46	Side move	29.5

The side move requires more time.

The Distance Factor: This series of motion patterns varied only in distance.

		Move Time
MP43	12 inches	27.3
MP45	16 inches	31.5
MP47	24 inches	34.6

Move time increased as distance increased.

Cans

One Hand Versus Two Hands: One expects the two hand work to require more time.

		Move Time
MP58	One hand (no orient)	23.6
MP60	Two hands (no orient)	25.1
MP64	One hand (orient)	27.7
MP69	Two hands (orient)	32.5
MP65	One hand (orient)	28.1
MP74	Two hands (orient)	33.1

Two hand motion patterns required more time.

Front Move Versus Side Move: A work place can be set up so that moves are to the side or to the front.

		Move Time
MP70	Front	33.8
MP71	Side	35.9

Moves to the side take longer.

303 Can Versus 46-ounce Can: The 303 can is only about one quarter the size of the 46-ounce can.

		Move Time
MP60	303 can (no orient)	25.1
MP62	46-ounce can (no orient)	31.6
MP69	303 can (orient)	32.5
MP75	46-ounce can (orient)	29.6

The first pair indicates that the heavier can requires more time, which is as one expects to find it. The second pair is an apparent discrepancy which is caused by more of the orienting being done during the move with the 303 can than was done with the 46-ounce can.

The Distance Factor: This series varied only in distance.

		Move Time
MP68	12 inch (orient)	26.7
MP69	18 inch (orient)	32.5
MP70	24 inch (orient)	33.8

Move time increased as distance increased.

Jars

The Size Factor: One pint and one quart jars were used.

		Move Time
MP76	Pint jar	30.2
MP79	Quart jar	34.9

Moves were longer for the quart jars.

Bottles

The Size Factor: Seven-ounce soft drink bottles and quart milk bottles were used.

		Move Time
MP83	Seven-ounce bottle	34.6
MP86	Quart milk bottle	37.2

Moves were longer for the quart bottles.

Bags

The Weight Factor: One-pound and two-pound paper bags were used.

		Move Time
MP90	One pound	26.7
MP93	Two pound	27.8

Moves were longer for the two-pound bags.

Boxes

The Weight Factor in Stocking Shelves with Boxes: Within each of the following series, weight was the only factor which varied.

		Move Time
MP98	1/2 pound (no orient)	24.8
MP101	1 pound (no orient)	27.0
MP104	2 1/2 pound (no orient)	27.8
MP107	5 pound (no orient)	32.5
MP110	1/2 pound (orient)	28.9
MP111	1 pound (orient)	30.6
MP112	2 1/2 pound (orient)	30.3
MP113	5 pound (orient)	37.9

Generally, move performance time increased as weight increased. However, the data indicates that the one-pound and 2 1/2-pound weights might well have gone into the same weight class.

The Weight Factor in Moving Boxes from Stack to Conveyor: The only factor which varied in this series was weight.

		Move Time
MP115	10 pound	26.2
MP116	25 pound	34.6
MP119	50 pound	39.3

Move time increased as weight increased.

The Distance Factor: Within these series distance was the only factor which varied.

		Move Time
MP114	18 inch (10 pound)	24.4
MP115	24 inch (10 pound)	26.2
MP116	24 inch (25 pound)	34.6
MP117	36 inch (25 pound)	36.7
MP118	48 inch (25 pound)	39.2

In each case move performance time increased as distance increased.

Summary

Moves require more time when both hands are employed than they do when only one hand is used. Move time increases as weight of object handled increases but at a much lower rate. Move time also increases as distance increases but at a much lower rate. When a sharp change of direction occurs during a move, performance time is increased substantially.

CHAPTER VI

GET AND PLACE: INVENTORY OF TIME DATA

The term get refers to the combination of reach and grasp. The term place refers to the combination of move and position-release. The reasons for using these combined forms instead of the complete motion breakdown have been indicated to some extent already. Insofar as film analysis is concerned, there is no real break point between reach and grasp, nor is there a real break point between move and position-release. In both cases, there is overlapping. The grasp actually begins before the reach ends, and the position begins before the move ends. There is no instant of time in which the one clearly ends and the other clearly begins.

The break points between reach and grasp and between move and position-release are not only indefinite but are also very time consuming to measure in film analysis. These break points can only be determined by arbitrary rules and the rules which apply for one motion pattern may not serve well at all for another.

The break points which occur at the end of the grasp and at the end of the release are much more easily recognized. There is a change of direction which is a big help in locating these break points. These are the break points used in the get and place breakdown of a motion pattern.

The inaccuracies of the complete motion breakdown lead the motion analysts into many blind alleys in their efforts to determine the effects of factors. They cannot separate real effects from discrepancies. There is actually a loss in accuracy of analysis when one attempts to go to complete motion breakdown. This is not nearly so true in analyzing get and place.

The break points for get and place are so much simpler to define and so much easier to recognize that one finds very little discrepancy in data when the same film is analyzed by different people. This is certainly not true in analyzing for motion data. Even when the same instructions are given to all film analysts, there will be very disturbing differences in the data from one analyst to another.

The simpler motion patterns have grasps and releases of such short duration that one is forced to use a fast camera speed if he intends to measure these adequately. Get and place provide longer elements which are more easily measured. Thirty two frames per second were considered necessary for the complete motion breakdown. Sixteen frames per second is most certainly adequate for get and place. It seems very likely that ten frames per second could be used satisfactorily for most work. The slower camera speeds save film which is quite expensive. They also save analysis time, which is even more expensive.

Since there seems to be no advantage peculiar to the complete motion breakdown and since there are several advantages peculiar to the get and place breakdown, it has been concluded that future studies should use the get place breakdown unless new reasons appear for doing otherwise.

The following data is largely the same as was presented in the complete motion breakdown. Note that the method description was not changed. The use of get and place refers only to the combinations for which time values are obtained. The complete motion breakdown, using therblig or basic motion terminology, is highly desirable for method description. The error of past thinking has been that performance time should be collected on this same micro-subdivision of work as is desirable for method description. One can describe a reach and a grasp quite accurately. He cannot, with any accuracy, measure performance time for the two motions independently.

Roughly Round or Oblong Fruits and Vegetables

The data in this section pertains to the handling of fruits and vegetables which are roughly round or oblong in shape. Specifically, the data was taken from the handling of apples, oranges, potatoes, lemons, grapefruit and cabbage. These commodities were classified according to weight.

The data obtained by holding the motion pattern and weight constant and varying the commodity shows but little change from one commodity to another. This indicates that the data can be used satisfactorily for commodities which are not included but which fit the same shape, size, and weight specifications.

Jumble Pack
Weight 1/4 to 3/4 Pound

In jumble packing, the fruit is moved from a bin or belt to a packing crate. No effort is made to place the fruit in a symmetrical pattern. They are simply released in the crate at random.

One Hand Only Used in Jumble Packing:

			Get	Place	Cycle
*MP1	Apples. Single grasp of one. From jumbled on flat surface. Move to crate. Single release. Side reach and move 12"	N**	18.4	19.2	37.6
		F	9.9	10.4	20.3
		R	.54	.54	.54

*Abbreviation for motion pattern.
**The letter "N" refers to normal rate performance time. The letter "F" refers to fast rate performance time. It is a measure of skill. The letter "R" refers to the ratio of fast to normal performance time.

			Get	Place	Cycle
MP2	Apples. Single grasp of one. From jumbled on flat surface. Move to crate. Single release. Side reach and move 24"	N	20.5	21.3	41.8
		F	13.2	13.1	26.3
		R	.64	.62	.63
MP3	Apples. Single grasp of one. From arranged line of apples on flat surface. Move to crate. Single release. Side reach and move 24"	N	21.3	21.5	42.8
		F	12.7	12.9	25.6
		R	.60	.60	.60
MP4	Apples. Single grasp of one. From jumbled on flat surface. Move to crate. Single release. Side reach and move 36"	N	26.4	27.1	53.5
		F	15.5	15.5	31.0
		R	.59	.57	.58

Two Hands Used in Jumble Packing

			Get	Place	Cycle
MP5	Apples. Single grasp one per hand. From jumbled on flat surface. Move to crate. Single release. Side reach and move 24"	N	26.3	25.4	51.7
		F	16.3	16.2	32.5
		R	.62	.64	.63
MP6	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 16"	N	31.2	24.1	55.3
		F	20.4	15.7	36.1
		R	.65	.65	.65
MP7	Apples. Simo grasp two per hand. From arranged pairs on flat surface. Move to crate. Simo release. Side reach and move 24"	N	30.2	26.6	56.8
		F	17.7	16.6	34.3
		R	.59	.62	.60
MP8	Potatoes. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	33.1	26.9	60.0
		F	23.2	17.7	40.9
		R	.72	.66	.68
MP9	Lemons. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	32.7	27.3	60.0
		F	23.3	18.1	41.4
		R	.71	.66	.69
MP10	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	33.8	27.5	61.3
		F	22.1	17.6	39.7
		R	.65	.64	.65

			Get	Place	Cycle
MP11	Oranges. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	34.9	28.1	63.0
		F	23.7	18.2	41.9
		R	.68	.65	.66
MP12	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 32"	N	36.6	31.4	68.0
		F	25.2	20.3	45.5
		R	.69	.65	.67
MP13	Apples. Pincer grasp two and one half per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	51.0	29.2	80.2
		F	38.4	20.0	58.4
		R	.75	.68	.73
MP14	Apples. Two plus one grasp three per hand. From jumbled on flat surface. Move to crate. Simo release. Side reach and move 24"	N	56.1	26.1	82.2
		F	42.1	20.3	62.4
		R	.75	.78	.76

Layer Packing
Weight 1/4 to 3/4 Pound

In layer packing the fruit is grasped from a bin or moving belt and placed in symmetrical rows, lines, and layers in the crate. Fruit is oriented so that cheeks are up and cores are parallel to the width of the crate.

One Hand Only Used in Layer Packing

			Get	Place	Cycle
MP15	Apples. Single grasp one per hand. From jumbled on flat surface. Move to single tilt crate. Single position-release. Side reach and move 24"	N	20.1	29.0	49.1
		F	14.5	20.6	35.1
		R	.72	.71	.71
MP16	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to single tilt crate. Consecutive position-release. Side reach and move 24"	N	28.0	59.6	87.6
		F	22.3	46.3	68.6
		R	.80	.78	.78

Two Hands Used in Layer Packing

			Get	Place	Cycle
MP17	Apples. Single grasp one per hand. From jumbled on flat surface. Move to double tilt crate. Single position-release. Side reach and move 24"	N	24.6	36.6	61.2
		F	17.6	26.4	44.0
		R	.72	.73	.72
MP18	Apples. Simo grasp two per hand. From arranged in pairs on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	31.0	76.5	107.5
		F	22.3	57.1	79.4
		R	.72	.75	.74
MP19	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	35.1	79.2	114.3
		F	27.6	61.6	89.2
		R	.79	.78	.78
MP20	Apples. Simo grasp two per hand. From jumbled on flat surface. Move to bottom of double tilt crate. Consecutive position-release. Side reach and move 24"	N	37.1	87.4	124.5
		F	28.3	69.0	97.3
		R	.76	.79	.78
MP21	Apples. Consecutive grasp two per hand. From jumbled on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	53.8	77.3	131.1
		F	38.4	61.7	100.2
		R	.71	.80	.76
MP22	Apples. Simo grasp two per hand. From jumbled in a box. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	39.6	91.5	131.1
		F	33.5	72.8	106.3
		R	.85	.80	.81
MP23	Apples. Consecutive grasp two per hand. From jumbled in a box. Move to double tilt crate. Consecutive position-release. Side reach and move 24"	N	59.0	81.9	140.9
		F	45.0	63.8	108.8
		R	.76	.78	.77

Wrapping and Packing Apples
Weight 1/4 to 3/4 Pound

			(1) Get tissue	(2) Place tissue in position for wrapping	(3) Wrap and place in crate	(4) Cycle
MP120	Apple. Throughout the cycle the work load is heavier for the left hand, consequently the work of the left hand determines the time requirements of the cycle. For that reason the analysis was based on the motions done by the left hand. Left hand (1) reach 12" to paper dispenser and grasped one tissue, (2) moved 12" to a position over the apples in the crate and transfer grasped apple from right hand. During this phase of the cycle, the right hand reached to belt, single grasped one apple, moved to left hand and transfer released apple onto tissue in left hand. From this point the left hand assisted by the right hand, (3) wraps tissue around apple, moves 12" to position in crate, positions and releases the wrapped apple in the proper position in the crate. After the right hand finishes the wrap motions, it moves toward the belt for another apple. Usually there is a balancing delay at about this point. The right hand must wait or at least slow down while the left hand disposes of the apple in the crate.	N	15.9	24.1	53.2	93.2
		F	13.0	17.0	38.3	68.3
		R	.82	.71	.72	.73

Fill Display Bin from Packing Crate
Weights 1, 2 & 3 Pounds

The grapefruit or cabbage was grasped from a packing crate, moved to a display bin, and released. No effort was made to produce a symmetrical pattern in the display bin.

Two Hands Used to Jumble in Display Bin

			Get	Place	Cycle
MP24	Grapefruit. One pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 18"	N	26.3	32.2	58.5
		F	16.6	18.5	35.1
		R	.63	.57	.60

			Get	Place	Cycle
MP25	Grapefruit. One pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 24"	N	28.7	31.3	60.0
		F	17.9	17.9	35.8
		R	.62	.57	.60
MP26	Grapefruit. One pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 36"	N	32.3	37.1	69.4
		F	20.4	20.7	41.1
		R	.63	.56	.59
MP27	Cabbage. Two pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 18"	N	28.5	35.8	64.3
		F	17.0	21.2	38.2
		R	.61	.58	.59
MP28	Cabbage. Two pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Front reach and move 24"	N	31.7	37.7	69.4
		F	19.0	21.5	40.5
		R	.60	.57	.58
MP29	Cabbage. Two pound. Single grasp one per hand. From jumbled in a box. Move to display bin. Single release. Side reach and move 36"	N	35.2	41.5	76.7
		F	22.0	25.5	47.5
		R	.62	.61	.62
MP30	Cabbage. Three pound. Two hand grasp of one. From jumbled in a box. Move to display bin. Two hand release of one. Front reach and move 18"	N	26.4	35.1	61.5
		F	16.2	18.8	35.0
		R	.61	.54	.57
MP31	Cabbage. Three pound. Two hand grasp of one. From jumbled in a box. Move to display bin. Two hand release of one. Front reach and move 24"	N	29.3	37.7	67.0
		F	17.9	21.6	39.5
		R	.61	.57	.59
MP32	Cabbage. Three pound. Two hand grasp of one. From jumbled in a box. Move to display bin. Two hand release of one. Side reach and move 36"	N	33.4	43.3	76.7
		F	19.7	26.3	46.0
		R	.59	.61	.60

Bunch Vegetables

The data for this section was obtained from the handling of celery. Motion pattern No. 33 was done with an artificial object which was made up to represent a bunch vegetable such as celery. It was thought that this object would not be significantly different. However, the data

shows a substantial difference. Although the data from this motion pattern is included in the inventory, it was not used in the table for bunch vegetables.

Fill Display Rack from Packing Crate
Weights Approximately 1 & 2 Pounds

The bunch vegetables were grasped from a packing crate, moved to display rack, and released.

Two Hands Used to Fill Display Rack:

			Get	Place	Cycle
MP33	Artificial bunch vegetable. One pound. Single grasp one per hand. From packing crate. Move to display rack. Single release. Front reach and move 18"	N	32.2	40.1	72.3
		F	20.8	24.6	45.4
		R	.65	.61	.63
MP34	Celery. One pound. Single grasp one per hand. From packing crate. Move to display rack. Single release. Front reach and move 24"	N	30.7	36.7	67.4
		F	18.4	21.9	40.3
		R	.60	.60	.60
MP35	Celery. One pound. Single grasp one per hand. From packing crate. Move to display rack. Single release. Side reach and move 36"	N	35.1	40.4	75.5
		F	22.7	24.4	47.1
		R	.65	.60	.62
MP36	Celery. Two pound. Single grasp one per hand. From packing crate. Move to display rack. Single release. Front reach and move 24"	N	29.3	37.6	66.9
		F	17.6	21.7	39.3
		R	.60	.58	.59
MP37	Celery. Two pound. Single grasp one per hand. From packing crate. Move to display rack. Single release. Side reach and move 24"	N	31.5	39.7	71.2
		F	19.2	24.6	43.8
		R	.61	.62	.62
MP38	Celery. Two pound. Single grasp one per hand. From packing crate. Move to display rack. Single release. Side reach and move 36"	N	35.1	44.3	79.4
		F	22.8	27.7	50.5
		R	.65	.63	.64

Eggs

All of the data for this section was taken from the handling of medium and large size eggs.

Loading Egg Grader

The eggs were grasped from a filled egg basket, moved to grader track, oriented so that the long axis of the egg lay across the two sides of the grader feed track, positioned on the feed track and released.

One Hand Only Used in Loading Egg Grader:

			Get	Place	Cycle
MP39	Eggs. Single grasp one egg. From egg basket. Move to track of egg grader. Single position-release. Front reach and move 12"	N	22.2	22.0	44.2
		F	14.3	13.7	28.0
		R	.64	.62	.63
MP40	Eggs. Simo grasp two eggs. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	33.6	52.5	86.1
		F	27.0	35.5	62.5
		R	.80	.68	.73
MP41	Eggs. Consecutive grasp two eggs. From an egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	48.9	49.2	98.1
		F	33.8	31.2	65.0
		R	.69	.63	.66

Two Hands Used in Loading Egg Grader:

MP42	Eggs. Single grasp one egg per hand. From egg basket. Move to track of egg grader. Single position-release. Front reach and move 12"	N	27.8	26.2	54.0
		F	18.2	16.3	34.5
		R	.65	.62	.64
MP43	Eggs. Simo grasp two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	42.6	64.2	106.8
		F	34.8	43.8	78.6
		R	.82	.68	.74
MP44	Eggs. Consecutive grasp two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 12"	N	57.3	56.7	114.0
		F	40.7	37.1	77.8
		R	.71	.65	.68

			Get	Place	Cycle
MP45	Eggs. Simo grasp two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 16"	N	46.5	68.1	114.6
		F	37.0	46.1	83.1
		R	.80	.68	.73
MP46	Eggs. Simo grasp two eggs per hand from egg basket. Move to track of egg grader. Consecutive position-release. Side reach and move 12"	N	46.7	68.2	114.9
		F	38.0	49.5	87.5
		R	.81	.73	.76
MP47	Eggs. Simo grasp of two eggs per hand. From egg basket. Move to track of egg grader. Consecutive position-release. Front reach and move 24"	N	52.3	68.5	120.8
		F	41.2	49.3	90.5
		R	.79	.72	.75

Packing Eggs

The eggs were grasped from the bin of an egg grader, moved to filler in an egg crate, oriented so that the pointed end is down, positioned over the cell in the filler, and released.

One Hand Only Used in Packing Eggs:

			Get	Place	Cycle
MP48	Egg. Single grasp of one egg. From grader bin. Move to case. Single position-release. Front reach and move 12"	N	21.8	22.6	44.4
		F	14.5	14.6	29.1
		R	.67	.65	.66

Two Hands Used in Packing Eggs:

MP49	Eggs. Single grasp of one egg per hand. From grader bin. Move to case. Single position-release. Front reach and move 12"	N	27.4	26.6	54.0
		F	18.2	17.1	35.3
		R	.66	.64	.65
MP50	Eggs. Simo grasp of two eggs per hand. From grader bin. Move to case. Consecutive position-release. Front reach and move 12"	N	39.3	61.8	101.1
		F	30.5	43.1	73.6
		R	.78	.70	.73
MP51	Eggs. Consecutive grasp of two eggs per hand. From grader bin. Move to case. Consecutive position-release. Front reach and move 12"	N	55.3	49.2	104.5
		F	41.5	35.4	76.9
		R	.75	.72	.74

			Get	Place	Cycle
MP52	Eggs. Consecutive grasp of two eggs per hand. From grader bin. Move to bottom of case. Consecutive position-release. Front reach and move 12"	N	59.9	56.7	116.6
		F	44.4	40.8	85.2
		R	.74	.72	.73
MP53	Eggs. Simo grasp of three eggs per hand. From grader bin. Move to case. Consecutive position-release of three eggs. Front reach and move 12"	N	61.8	98.6	160.4
		F	48.1	70.1	118.2
		R	.78	.71	.74
MP54	Eggs. Two plus one grasp of three eggs per hand. From grader bin. Move to case. Consecutive position-release of three eggs. Front reach and move 12"	N	81.5	81.6	163.1
		F	65.1	60.5	125.6
		R	.80	.74	.77

Weighing Eggs on Single Egg Scale

Eggs were grasped from an egg basket, moved to the cup of the egg scale, positioned over the cup, and released. Then they were grasped from the scale cup, moved to other hand and transfer released.

One Hand Used in Weighing Eggs:

			Get	Place	Cycle
MP55	Egg. Single grasp of one egg. From cup of egg scales. Move to other hand. Transfer release. Front reach and move 12"	N	22.4	19.3	41.7
		F	14.3	12.1	26.4
		R	.64	.63	.63
MP56	Egg. Single grasp of one egg. From egg basket. Move to cup of egg scales. Single position-release. Front reach and move 12"	N	22.2	23.6	45.8
		F	14.1	14.7	28.8
		R	.64	.62	.63

Cans

Most of the data in this section was obtained from the handling of No. 303 cans. Some preliminary tests indicated that there would be very little difference in performance time for the buffet, number two and one half sizes. The Number 303 was selected to represent these smaller sizes. Some motion patterns were done with the 46 ounce juice cans. These showed a substantial difference from the smaller cans.

Stocking Shelves with Cans - Labels Not Oriented

Cans were grasped from case, moved to shelf, positioned over a single layer of cans already on the shelf, and released. No attention was paid to direction of labels.

One Hand Used in Stocking Shelves:

			Get	Place	Cycle
MP57	303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Front reach and move 12"	N	24.6	32.9	57.5
		F	15.2	17.8	33.0
		R	.62	.54	.57
MP58	303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Front reach and move 18"	N	24.5	32.1	56.6
		F	18.0	20.7	38.7
		R	.73	.64	.68
MP59	303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Side reach and move 36"	N	31.6	45.1	76.7
		F	21.3	28.0	49.3
		R	.67	.62	.64

Two Hands Used in Stocking Shelves:

MP60	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	31.3	39.1	70.4
		F	22.0	25.6	47.6
		R	.70	.65	.68
MP61	303 can. Simo grasp of two cans per hand. From case. Move to shelf. Simo position-release. Front reach and move 18"	N	49.1	57.4	106.5
		F	34.0	35.2	69.2
		R	.69	.61	.65
MP62	46 ounce can. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	34.1	44.2	78.3
		F	21.5	26.6	48.1
		R	.63	.60	.61
MP63	46 ounce can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	40.3	59.0	99.3
		F	26.5	37.5	64.0
		R	.66	.64	.64

Stocking Shelves with Cans - Labels Oriented to Face Customers

Cans were grasped from case, moved to shelf, labels oriented so that they faced outward from the shelf, positioned over a single layer of cans already on the shelf, and released.

One Hand Only Used in Stocking Shelves:

			Get	Place	Cycle
MP64	303 can. Single grasp of one can. From case. Move to shelf. Single position-release. Front reach and move 18"	N	25.7	46.4	72.1
		F	19.8	30.7	50.5
		R	.77	.66	.70
MP65	303 can. Simo grasp of two cans. From case. Move to shelf. Consecutive position-release. Front reach and move 18"	N	40.4	98.0	138.4
		F	33.6	68.3	101.9
		R	.83	.70	.74

Two Hands Used in Stocking Shelves:

MP66	303 can. Transfer grasp of one can. From left hand. Move to shelf. Single position-release. Front reach and move 18" (The cans were obtained from case by the left hand.)	N	26.1	33.8	59.9
		F	19.3	23.7	43.0
		R	.74	.70	.72
MP67	303 can with 2-sided label. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	31.5	46.2	77.7
		F	22.8	29.6	52.4
		R	.72	.64	.67
MP68	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 12"	N	31.0	59.2	90.2
		F	22.4	39.7	62.1
		R	.72	.67	.69
MP69	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	32.5	61.2	93.7
		F	24.1	42.8	66.9
		R	.74	.70	.71
MP70	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	37.9	61.9	99.8
		F	26.9	45.3	72.2
		R	.71	.73	.72

			Get	Place	Cycle
MP71	303 can. Single grasp of one can per hand. From case. Move to shelf. Single position-release. Side reach and move 24"	N	36.9	64.5	101.4
		F	26.8	47.7	74.5
		R	.73	.74	.73
MP72	303 can. Single grasp of one can per hand. From case move to shelf. Single position-release. Side reach and move 36"	N	40.4	69.8	110.2
		F	30.9	53.3	84.2
		R	.76	.76	.76
MP73	303 can. Simo grasp of three cans with both hands. From case. Move to shelf. Use both hands to position-release the three cans. Front reach and move 18"	N	43.3	101.2	144.5
		F	33.1	79.9	113.0
		R	.76	.79	.78
MP74	303 can. Simo grasp of two cans per hand. From case. Move to shelf. Consecutive position-release. Front reach and move 18"	N	47.5	135.5	183.0
		F	38.7	106.4	145.1
		R	.81	.79	.79
MP75	46 ounce can single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	36.5	70.1	106.6
		F	26.0	52.0	78.0
		R	.71	.74	.73

Glass Jars

The data in this section was obtained from the handling of pint and quart glass jars. All data was taken from two handed operations.

Stocking Shelves with Jars - Labels Not Oriented

Jars were grasped from a case which had a cardboard separator in in forming an individual cell for each jar, moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP76	Pint glass jar. Single grasp of one jar per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	33.3	40.0	73.3
		F	21.4	22.6	44.0
		R	.64	.56	.60

			Get	Place	Cycle
MP77	Pint glass jar. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	36.1	41.7	77.8
		F	25.0	24.8	49.8
		R	.69	.59	.64
MP78	Pint glass jars. Single grasp of one jar per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	39.4	49.3	88.7
		F	27.5	31.0	58.5
		R	.70	.63	.66
MP79	Quart glass jar. Single grasp of one jar per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	32.3	46.1	78.4
		F	21.8	29.3	51.1
		R	.67	.64	.65
MP80	Quart glass jar. Single grasp of one jar per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	36.4	49.1	85.5
		F	24.8	31.5	56.3
		R	.68	.64	.66
MP81	Quart glass jar. Single grasp of one jar per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	39.6	58.5	98.1
		F	26.4	38.7	65.1
		R	.67	.66	.66

Stocking Shelves with Jars - Labels Oriented to Face Customers

Jars were grasped from a case which had a cardboard separator in it forming an individual cell for each jar, moved to shelf, oriented so that jar labels faced outward from shelf, positioned on shelf and released.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP82	Pint glass jar. Single grasp of one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	34.7	62.4	97.1
		F	26.1	43.1	69.2
		R	.75	.69	.71

Glass Bottles

The data in this section was obtained from the handling of seven ounce soft drink bottles and quart milk bottles.

Stocking Shelves with Bottles - Labels Not Oriented

The seven ounce bottles were grasped from a wooden case without separators. The quart milk bottles were grasped from a metal crate with metal separators which formed an individual cell for each bottle. Bottles were moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP83	Seven ounce bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	28.6	45.9	74.5
		F	17.8	27.3	45.1
		R	.62	.59	.61
MP84	Seven ounce bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	30.8	47.8	78.5
		F	19.4	28.6	48.0
		R	.63	.60	.61
MP85	Seven ounce bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	34.9	54.7	89.6
		F	23.3	36.0	59.3
		R	.67	.66	.66
MP86	Quart milk bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	28.6	51.3	79.9
		F	16.7	31.4	48.1
		R	.58	.61	.60
MP87	Quart milk bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	32.2	54.5	86.7
		F	18.9	34.0	52.9
		R	.59	.62	.61
MP88	Quart milk bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	36.1	64.1	100.2
		F	23.7	43.1	66.8
		R	.66	.67	.67

Stocking Shelves with Bottles - Labels Oriented to Face Customers

Seven ounce bottles were grasped from a wooden case without separators, moved to shelf, oriented so that labels faced outward from the shelf, positioned on the shelf, and released.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP89	Seven ounce bottle. Single grasp one bottle per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	29.0	57.8	86.8
		F	20.4	41.6	62.0
		R	.70	.72	.71

Bags

The data in this section was obtained from the handling of one and two pound paper bags, and 25 pound burlap bags. All of the data was taken from two handed operations.

Stocking Shelves with Bags - Labels Not Oriented

Bags were grasped from a case, moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP90	One pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	35.8	37.2	73.0
		F	21.8	22.0	43.8
		R	.61	.59	.60
MP91	One pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	37.0	39.5	76.5
		F	24.4	24.6	49.0
		R	.66	.62	.64
MP92	One pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	40.9	46.8	87.7
		F	27.2	30.0	57.2
		R	.66	.64	.65
MP93	Two pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	36.5	36.9	73.4
		F	22.2	21.0	43.2
		R	.61	.57	.59
MP94	Two pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	39.7	40.4	80.1
		F	24.9	23.2	48.1
		R	.63	.57	.60

			Get	Place	Cycle
MP95	Two pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	44.0	49.9	93.9
		F	27.7	30.1	57.8
		R	.63	.60	.62

Stocking Shelves with Bags - Labels Oriented to Face Customers

Bags were grasped from a case, moved to shelf, oriented so that labels faced outward from the shelf, positioned on the shelf, and released.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP96	One pound bag. Single grasp one per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	36.8	51.0	87.8
		F	26.8	35.3	62.1
		R	.73	.69	.71

Moving Large Bags from Stack to Conveyor

Bags were grasped from a stack, moved horizontally from left to right, and released on a conveyor.

Two Hands Used to Load Conveyor:

			Get	Place	Cycle
MP97	25 pound bag. Grasp one with both hands. From stack. Move to conveyor. Single release. Side reach and move 24"	N	33.4	36.1	69.5
		F	17.4	20.7	38.1
		R	.52	.57	.55

Boxes

The data in this section was obtained from the handling of boxes of the following weights: 1/2 pound, 1 pound, 2 1/2 pounds, 5 pounds, 10 pounds, 25 pounds, and 50 pounds.

Stocking Shelves with Boxes - Labels Not Oriented

Boxes were grasped from a case, moved to shelf, positioned on shelf, and released. No attention was paid to direction of labels.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP98	1/2 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	33.0	38.5	71.5
		F	20.0	20.1	40.1
		R	.61	.52	.56
MP99	1/2 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	36.6	40.2	76.8
		F	22.5	22.2	44.7
		R	.61	.55	.58
MP100	1/2 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	40.8	47.9	88.7
		F	26.8	27.9	54.7
		R	.66	.58	.62
MP101	1 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	32.7	40.5	73.2
		F	19.9	21.8	41.7
		R	.61	.54	.57
MP102	1 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	35.1	43.1	78.2
		F	22.0	24.1	46.1
		R	.63	.56	.59
MP103	1 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	39.9	52.9	92.8
		F	26.3	31.5	57.8
		R	.66	.60	.62
MP104	2½ pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	32.6	42.0	74.6
		F	18.6	22.0	40.6
		R	.57	.52	.54
MP105	2½ pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	34.7	45.6	80.3
		F	21.8	25.0	46.8
		R	.63	.55	.58

			Get	Place	Cycle
MP106	2½ pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	40.8	54.4	95.2
		F	24.8	32.7	57.5
		R	.61	.60	.60
MP107	5 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	35.5	48.6	84.1
		F	21.8	27.4	49.2
		R	.61	.56	.58
MP108	5 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 24"	N	40.1	54.9	95.0
		F	24.3	30.9	55.2
		R	.61	.56	.58
MP109	5 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Side reach and move 36"	N	44.4	65.7	110.1
		F	28.8	39.8	68.6
		R	.65	.61	.62

Stocking Shelves with Boxes - Labels Oriented to Face Customers

Boxes were grasped from a case, moved to shelf, oriented so that labels faced outward from shelf, positioned on shelf, and released.

Two Hands Used to Stock Shelves:

			Get	Place	Cycle
MP110	1/2 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	33.7	47.3	81.0
		F	25.8	32.5	58.3
		R	.77	.69	.72
MP111	1 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	33.2	50.8	84.0
		F	25.5	36.3	61.8
		R	.77	.71	.74
MP112	2½ pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	32.4	53.3	85.7
		F	24.0	37.2	61.2
		R	.74	.70	.71
MP113	5 pound box. Single grasp one box per hand. From case. Move to shelf. Single position-release. Front reach and move 18"	N	39.3	66.8	106.1
		F	27.1	45.9	73.0
		R	.69	.69	.69

Move Large Boxes from Stack to Conveyor

Boxes were grasped from a stack, moved horizontally from left to right, and released on a conveyor.

Two Hands Used to Load Conveyor:

			Get	Place	Cycle
MP114	10 pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 18"	N	28.5	30.4	58.9
		F	15.3	16.7	32.0
		R	.54	.55	.54
MP115	10 pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 24"	N	30.1	31.7	61.8
		F	15.6	18.4	34.0
		R	.52	.58	.55
MP116	25 pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 24"	N	36.3	42.0	78.2
		F	20.6	25.3	45.9
		R	.57	.60	.59
MP117	25 pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 36"	N	40.0	44.7	84.7
		F	22.6	27.6	50.2
		R	.56	.62	.59
MP118	25 pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 48"	N	45.9	49.1	95.0
		F	27.0	32.4	59.4
		R	.59	.66	.63
MP119	50 pound box. Grasp one box with both hands. From stack. Move to conveyor. Release one with both hands. Side reach and move 24"	N	38.8	49.9	88.7
		F	22.8	30.7	53.5
		R	.59	.62	.60

CHAPTER VII

GET AND PLACE: EVALUATION OF SKILL IN GRASPS

Get is the combination of reach and grasp. Reach is the travel portion of this combination and its performance time is governed in the main by level of effort. The grasp is the manipulative portion and it is governed in a larger degree by the level of skill. In film analysis of reach and grasp, the reach appears to be affected by skill content. If the grasp is complex or requires precision of movement, the reach time will be longer than when a simpler grasp is employed. Fundamentally, this is because of the overlapping of reach and grasp. In other words, the reach is longer because of the nature of the grasp. The extra time required to perform the reach in such situations could be more accurately attributed to the grasp. It is both logical and expedient to attribute the skill of the get combination to the grasp.

When a person is performing a very low skill motion pattern at a normal rate of speed, he can voluntarily reduce his performance time to about 50-60 per cent with no great difficulty. If a fair degree of skill is required to perform the motion pattern, he cannot reduce his performance time quite as much. As the skill content of a motion pattern increases, the worker becomes increasingly restricted in his application of effort. In this section that characteristic is used to provide a measure of the skill content of grasp. If he pushes effort to too high a level, he begins to fumble. That is his limitation.

The actual measurement of skill is made by dividing the fast average by the normal average for a particular motion pattern. The closer this quotient is to one, the more skill the particular get has in it. Since the grasp is really the skill portion of the get, the measure may be interpreted as measuring the skill content of the grasp.

Any change in the skill factors constitutes a change in method also. However, there are certain types of changes in method which do not involve a measurable change in skill content. Sometimes two or more types of a motion will have virtually the same level of skill requirements but be quite different in method and also in time requirements. Since virtually all methods changes are reflected in performance time requirements, time data will also be considered.

Round or Oblong Fruits and Vegetables

The evaluations are made on the basis of easily recognized characteristics of the motion pattern. Comparisons are made of matched pairs or matched series of motion patterns. These matched pairs or matched series of motion patterns are alike in all factors except the one being measured. When the effect of distance is being evaluated, the same number of hands will be used throughout the series, the same type of grasp, the same objects grasped and the same type of release. The

motion patterns will vary only in distance; consequently the effect of distance will not be confused with the effect of any other factor. By using this technique of matched pairs or matched series, the effect of each factor can be quite effectively isolated.

Inventory of Data

Grasps Which Occur in Jumble Packing Fruits and Vegetables, 1/4 to 3/4 Pounds in Weight:

		Skill	Time
MP1	One hand single grasp of an apple from jumbled on a flat surface. Reach 12"	.54	18.4
MP2	One hand single grasp of one apple from jumbled on a flat surface. Reach 24"	.64	20.5
MP3	One hand single grasp of an apple from arranged line on a flat surface. Reach 24"	.60	21.3
MP4	One hand single grasp of an apple from jumbled on a flat surface. Reach 36"	.59	26.4
MP5	Two hand single grasp of one apple per hand from jumbled on a flat surface. Reach 24"	.62	26.3
MP6	Two hand simo grasp of two apples per hand from arranged pairs on a flat surface. Reach 24"	.65	31.2
MP7	Two hand simo grasp of two apples per hand from arranged pairs on a flat surface. Reach 24"	.59	30.2
MP8	Two hand simo grasp of two potatoes per hand from jumbled on a flat surface. Reach 24"	.72	33.1
MP9	Two hand simo grasp of two lemons per hand from jumbled on a flat surface. Reach 24"	.71	32.7
MP10	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.65	33.8
MP11	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.68	34.9
MP12	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 32"	.69	36.6
MP13	Two hand pincer grasp of two and a half apples per hand from jumbled on a flat surface. Reach 24"	.75	51.0

		Skill	Time
MP14	Two hand two plus one grasp of three apples per hand from jumbled on a flat surface. Reach 24"	.75	56.1

Grasps Which Occur in Layer Packing Apples, 1/4 to 3/4 Pound in Weight:

MP15	One hand single grasp of one apple from jumbled on a flat surface. Reach 24"	.72	20.1
MP16	One hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.80	28.0
MP17	Two hand single grasp of one apple per hand from jumbled on a flat surface. Reach 24"	.72	24.6
MP18	Two hand simo grasp of two apples per hand from arranged in pairs on a flat surface. Reach 24"	.72	31.0
MP19	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.79	35.1
MP20	Two hand simo grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.76	37.1
MP21	Two hand consecutive grasp of two apples per hand from jumbled on a flat surface. Reach 24"	.71	53.8
MP22	Two hand simo grasp of two apples per hand from jumbled in a box. Reach 24"	.85	39.6
MP23	Two hand consecutive grasp of two apples per hand from jumbled in a box. Reach 24"	.76	59.0

Grasps Used in Stocking Fruit Bin From Packing Crate, Weights Approximately One, Two, and Three Pounds:

MP24	Two hand single grasp of a one-pound grapefruit per hand from jumbled in a box. Reach 18"	.63	26.3
MP25	Two hand single grasp of a one-pound grapefruit per hand from jumbled in a box. Reach 24"	.62	28.7
MP26	Two hand single grasp of a one-pound grapefruit per hand from jumbled in a box. Reach 36"	.63	32.3

		Skill	Time
MP27	Two hand single grasp of a two-pound cabbage per hand from jumbled in a box. Reach 18"	.61	28.5
MP28	Two hand single grasp of a two-pound cabbage per hand from jumbled in a box. Reach 24"	.60	31.7
MP29	Two hand single grasp of a two-pound cabbage per hand from jumbled in a box. Reach 36"	.62	35.2
MP30	Two hand grasp with both hands one three-pound cabbage from jumbled in a box. Reach 18"	.61	26.4
MP31	Two hand grasp with both hands one three-pound cabbage from jumbled in a box. Reach 24"	.61	29.3
MP32	Two hand grasp with both hands a three-pound cabbage from jumbled in a box. Reach 36"	.59	33.4

Skill and Method Evaluations

Some skill characteristics are obvious, some are not. Since the skill measure coincided with personal judgment in most cases where the presence of skill elements were clearly recognized, it seemed safe to assume that it would do as well on those not identified.

Usually, the first motion pattern in a pair or series is, in the project staff's collective judgment, the lower or lowest in skill content. However, there were instances when there was very little basis for selection.

One Hand Versus Two Hand: Occasionally one will observe a worker employing only one hand in the performance of his work. The other hand is idle. Some methods' engineers have assumed that nearly twice as much work would be accomplished if both hands were used. The following data, it is believed, closely approximates the true relationship.

		Skill	Time
MP2	One hand (jumble pack)	.64	20.5
MP5	Two hand (jumble pack)	.62	26.3
MP15	One hand (layer pack)	.72	20.1
MP17	Two hand (layer pack)	.72	24.6

		Skill	Time
MP16	One hand (layer pack)	.80	28.0
MP19	Two hand (layer pack)	.79	35.1

Skill: One would expect the skill requirements to be higher for two hand work. The data shows virtually no difference. If the data can be relied upon, there is no significant difference between one and two hand work for these motion patterns.

Time: The time data indicates quite clearly that the get using both hands takes longer to perform than the get using only one hand. The two hand get of the first pair took 28 per cent longer; for the second pair, 22 per cent longer; and for the last pair, 25 per cent longer. The work accomplished was doubled.

Grasp Types Used in Jumble Packing: All of the grasps in this series were made from a flat surface such as the bottom of a packing bin or a moving belt. The single grasp refers to a simple grasp of only one object. The simo grasp refers to the grasping of two objects simultaneously. Where two objects are separated by a few inches, the first one is slid along the surface until the two are adjacent before the grasp is completed. The grasp is performed as nearly simultaneously as is possible. The pincer grasp refers to a simo grasp of two apples per hand followed by grasping another between the middle fingers of the two hands. Both hands grasp a total of five objects in the pincer grasp. The two-plus-one grasp refers to a three object grasp. First, two objects are grasped simultaneously, then a third is obtained by placing the middle finger over it and holding it against the first two.

		Skill	Time
MP5	Single grasp	.62	26.3
MP10	Simo grasp	.65	33.8
MP13	Pincer grasp	.75	51.0
MP14	Two-plus-one grasp	.75	56.1

Skill: Note that as the grasps become more complex, the skill content rises. This is as one would expect.

Time: In each case, as the grasp became more complex and the work load increased, the performance time also increased.

Grasps Used in Layer Packing: Some of the grasps were made from a flat surface such as the bottom of a bin or a moving belt. Some were made from fruit jumbled in depth such as one would find in a filled bin or box.

The single grasp refers to a simple grasp of one apple. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the first apple, then a second grasp of another apple with the same hand. The simo grasp refers to a simultaneous grasp of two apples in the same hand. In actual practice, the simo grasp was not always completely simultaneous because one apple would be a few inches from another. In such cases the first apple would be slid along until the second could be grasped.

		Skill	Time
MP17	Single grasp (from flat surface)	.72	24.6
MP21	Consecutive grasp (from flat surface)	.71	53.8
MP19	Simo grasp (from flat surface)	.79	35.1
MP23	Consecutive grasp (from box)	.76	59.0
MP22	Simo grasp (from box)	.85	39.6

Skill: The data shows that there is very little difference in skill content between the single grasp and consecutive grasp. The data also shows that the simo grasp requires substantially more skill than either of the other two types.

Time: The simo grasp shows the lowest performance time per apple.

Fruit Arranged in Uniform Pattern Versus Jumbled: The fruit on a packing belt would be in jumbled pattern. In order to determine what effect this random arrangement had, an artificially uniform and symmetrical arrangement was set up. The fruit was spaced evenly in a straight line, either singly or in pairs. In the first set of pairs, the single grasp was used. In the second and third sets, the simo grasp was used.

		Skill	Time
MP3	Arranged (jumble pack)	.60	21.3
MP2	Jumbled (jumble pack)	.64	20.5
MP7	Arranged (jumble pack)	.59	30.2
MP10	Jumbled (jumble pack)	.65	33.8

		Skill	Time
MP18	Arranged (layer pack)	.72	31.0
MP19	Jumbled (layer pack)	.79	35.1

Skill: The arranged pattern showed a lower skill content in all three sets of matched pairs.

Time: When the single grasp was used, it made little difference whether the fruit was arranged or jumbled. However, it took about 12 per cent longer to make simo grasps from the jumbled arrangement. It is quite obvious that jumbling adds more work to simo grasps than to single grasps.

Different Commodities of About the Same Size and Weight: Although the main body of data in this section was obtained from the handling of apples, it was intended to serve for other fruits of a similar size, shape, and weight. In order to determine whether the data actually could be used for other commodities, several others were tried for comparison.

		Skill	Time
MP10	Apples	.65	33.8
MP11	Oranges	.68	34.9
MP9	Lemons	.71	32.7
MP8	Potatoes	.72	33.1

Skill: The data indicates a slightly higher skill requirement for grasping oranges. If this difference is significant, it is very likely due to the fact that the oranges were more nearly round in shape and tended to roll quite easily. This appeared to make the grasps a little more difficult.

The data indicates substantially more skill is required for grasping lemons. The difference is wide enough that it must be of some significance. The reasons are perhaps that the oblong shape and the tendency of lemons to roll make for more difficult grasping.

Potatoes also appear to require substantially more skill than apples. This is probably due to the fact that potatoes are not as uniform in size and shape.

Time: The tendency of the oranges to roll apparently increased the performance time slightly. It took three per cent more time for the get when oranges were handled. This does not indicate that any great discrepancy will be encountered if the data obtained from handling apples is applied to the handling of oranges.

The get time for lemons was three per cent less and for potatoes five per cent less than for apples. The discrepancy of applying data from handling apples to the handling of lemons or potatoes would not appear to be very great.

Jumbled on a Flat Surface Versus Jumbled in Depth: Sometimes the grasps are made from the flat surface of the bottom of a bin or from the flat surface of a belt. In other cases fruit is grasped from a filled bin or field crate where it is jumbled in depth.

		Skill	Time
MP21	Flat surface	.71	53.8
MP23	Depth	.76	59.0
MP19	Flat surface	.79	35.1
MP22	Depth	.85	39.6

Skill: In actually performing these grasps, it is quite noticeable that they are more difficult when the fruit is jumbled in depth. The data in both sets of pairs shows a substantially higher skill content for grasps of fruit jumbled in depth.

Time: Jumbling in depth also increased the work load and the time requirements. In the case of consecutive grasps, jumbling in depth increased performance time by 10 per cent. In the case of simo grasps, jumbling in depth increased the performance time by 13 per cent.

Top of Crate Versus Bottom of Crate: In both cases the distance was the same. The factor which is measured here is the change of directions which occurs in the reach when packing in the bottom of the crate.

		Skill	Time
MP19	Top of crate	.79	35.1
MP20	Bottom of crate	.76	37.1

Skill: Only the reach is affected by the change of direction. The grasp is the same for both. No great difference would be expected for the skill content. The data does not show a very great difference and perhaps this difference is not significant.

Time: The change of direction which occurs in the reach would be expected to slow down the rate of performance. The get with the change of direction took 6 per cent longer.

The Distance Factor: Within each of the following five series of motion patterns, distance was the only factor which varied.

		Skill	Time
MP1	12 inches (apples)	.54	18.4
MP2	24 inches (apples)	.64	20.5
MP4	36 inches (apples)	.59	26.4
MP6	16 inches (apples)	.65	31.2
MP10	24 inches (apples)	.65	33.8
MP12	32 inches (apples)	.69	36.6
MP24	18 inches (one-pound grapefruit)	.63	26.3
MP25	24 inches (one-pound grapefruit)	.62	28.7
MP26	36 inches (one-pound grapefruit)	.63	32.3
MP27	18 inches (two-pound cabbage)	.61	28.5
MP28	24 inches (two-pound cabbage)	.60	31.7
MP29	36 inches (two-pound cabbage)	.62	35.2
MP30	18 inches (three-pound cabbage)	.61	26.4
MP31	24 inches (three-pound cabbage)	.61	29.3
MP32	36 inches (three-pound cabbage)	.59	33.4

Skill: Distance is not a skill factor and although there are some variations within these five series of data, they are not believed to be significant. The skill content of all five of these series is low.

Time: In each case, when distance increased, the time requirements also increased, but not in the same proportion. The percentage increase in performance time was very small in comparison to the changes in distance.

The Weight Factor: The same motion pattern was used for both the one-pound grapefruit and the two-pound cabbage.

		Skill	Time
MP24	One pound (18 inches)	.63	26.3
MP27	Two pound (18 inches)	.61	28.5
MP25	One pound (24 inches)	.62	28.7
MP28	Two pound (24 inches)	.60	31.7
MP26	One pound (36 inches)	.63	32.3
MP29	Two pound (36 inches)	.62	35.2

Skill: In every pair, the data shows slightly lower skill content in the two-pound weight. The difference is very slight and is not believed to be significant.

Time: At each of three distances the two-pound weight required 11 per cent more time than the one-pound weight. The effect of the added weight was quite uniform.

Summary of Skill Evaluations for Grasps of Round Fruits and Vegetables

The following conclusions seem to be indicated. Using both hands simultaneously required about the same skill as using just one hand for these motion patterns. Types of grasp in order of increasing skill requirements are single, consecutive, simo, and grasps of more than two objects per hand (pincer and two-plus-one). The data gives no clear indication of a choice between the last two. It requires more skill to grasp objects jumbled on a flat surface than it does when they are arranged in a uniform pattern. When they are jumbled in depth such as they would be when grasped from a filled bin or crate, even more skill is required. Oranges, lemons, and potatoes appear to require a little more skill to grasp than apples. The one, two and three pound objects do not appear to require any more skill to handle than the smaller fruits and vegetables. Very definitely grasping apples for layer packing requires more skill than when grasping for jumble packing.

Summary of Time Evaluations for Gets of Round Fruits and Vegetables

In almost every instance where there is a variation in skill content, the performance time also has changed. However, increases in

skill content do not always mean increases in performance time. In addition to those changes which are significant both as skill and performance time changes, there are a few factors which cause substantial changes in performance time with no measurable difference in skill content.

One method variation which shows no certain relationship to skill content is distance. As distance is increased, performance time increases but at a much lower rate.

Weight is another variable which shows no certain relationship to skill content. As weight increases, performance time increases but at a much lower rate.

The necessity for making a sharp change of direction during a reach increases the performance time but does not have any certain relationship with skill content.

Bunch Vegetables

There is no skill factor represented in the motion patterns which were used in handling bunch vegetables. There are, however, two method variations which affect performance time. These are distance and weight.

Inventory of Data

		Skill	Time
MP33	Two hand single grasp of a one-pound artificial bunch vegetable per hand from a packing crate. Reach 18"	.65	32.2
MP34	Two hand single grasp of a one-pound celery per hand from packing crate. Reach 24"	.60	30.7
MP35	Two hand single grasp of a one-pound celery per hand from packing crate. Reach 36"	.65	35.1
MP36	Two hand single grasp of a two-pound celery per hand from packing crate. Reach 18"	.60	29.3
MP37	Two hand single grasp of a two-pound celery per hand from packing crate. Reach 24"	.61	31.5
MP38	Two hand single grasp of a two-pound celery per hand from packing crate. Reach 36"	.65	35.1

The Weight Factor: The same motion pattern is used in both the one- and two-pound celery handling. Weight is the factor measured.

		Skill	Time
MP33	One pound	.65	32.2
MP36	Two pound	.60	29.3
MP34	One pound	.60	30.7
MP37	Two pound	.61	31.5
MP35	One pound	.65	35.1
MP38	Two pound	.65	35.1

Skill: There is no definite direction to the skill measure and one would not expect one. Weight is not a skill characteristic.

Time: One should not expect much response of get to changes in weight since the hands are empty during this phase of the cycle. The data shows no definite direction.

The Distance Factor: Each of the two series is matched in all characteristics but distance.

		Skill	Time
MP34	24 inches	.60	30.7
MP35	36 inches	.65	35.1
MP36	18 inches	.60	29.3
MP37	24 inches	.61	31.5
MP38	36 inches	.65	35.1

Skill: The data indicates that there is some increase in skill as distance increases.

Time: In each case, the performance time increased as distance increased but not nearly as much.

Eggs

The additional factor of fragility is introduced in egg handling. It is quite apparent in observing the work that fragility is of considerable significance.

Inventory of Data

Grasps Which Occur in Loading Egg Grader:

		Skill	Time
MP39	One hand single grasp of one egg from egg basket. Reach 12"	.64	22.2
MP40	One hand simo grasp of two eggs from egg basket. Reach 12"	.80	33.6
MP41	One hand consecutive grasp of two eggs from egg basket. Reach 12"	.69	48.9
MP42	Two hand single grasp of one egg per hand from egg basket. Reach 12"	.65	27.8
MP43	Two hand simo grasp of two eggs per hand from egg basket. Reach 12"	.82	42.6
MP44	Two hand consecutive grasp of two eggs per hand from egg basket. Reach 12"	.71	57.3
MP45	Two hand simo grasp of two eggs per hand from egg basket. Reach 16"	.80	46.5
MP46	Two hand simo grasp of two eggs per hand from egg basket. Side reach 12"	.81	46.7
MP47	Two hand simo grasp of two eggs per hand from egg basket. Reach 24"	.79	52.3

Grasps Which Occur in Packaging Eggs:

MP48	One hand single grasp of one egg from grader bin. Reach 12"	.67	21.8
MP49	Two hand single grasp of one egg per hand from grader bin. Reach 12"	.66	27.4
MP50	Two hand simo grasp of two eggs per hand from grader bin. Reach 12"	.78	39.3

		Skill	Time
MP51	Two hand consecutive grasp of two eggs per hand from grader bin. Reach 12"	.75	55.3
MP52	Two hand consecutive grasp of two eggs per hand from grader bin. Reach from bottom of case 12"	.74	59.9
MP53	Two hand simo grasp of three eggs per hand from grader bin. Reach 12"	.78	61.8
MP54	Two hand two-plus-one grasp of three eggs per hand from grader bin. Reach 12"	.80	81.5

Grasps Used in Weighing Eggs on Single Egg Scale:

MP55	One hand single grasp of one egg from cup of egg scales. Reach 12"	.64	22.4
MP56	One hand single grasp of one egg from egg basket. Reach 12"	.64	22.2

Evaluation of Skill and Method

The following evaluations take into account method variations which affect skill content and those which do not. The evaluations are based on matched pairs or matched series.

One Hand Versus Two Hand: Frequently one observes a person working with only one hand. Methods engineers have sometimes assumed that work output could be nearly doubled by using both hands. These data present a measure of the relation between one hand and two hand work.

		Skill	Time
MP39	One hand (grading)	.64	22.2
MP42	Two hand (grading)	.65	27.8
MP41	One hand (grading)	.69	48.9
MP44	Two hand (grading)	.71	57.3
MP40	One hand (grading)	.80	33.6
MP43	Two hand (grading)	.82	42.6

		Skill	Time
MP48	One hand (packing)	.67	21.8
MP49	Two hand (packing)	.66	27.4

Skill: Three out of the four pairs show a slight increase of skill when two hands are used. The difference is so slight that it could not be called significant, however.

Time: In every case the two hand get required longer to perform. The performance time increased but little; however, when compared to the increase in work accomplished per get.

Grasp Types Used in Egg Grading: Several types of grasp are used in grading. All of these were made from an egg basket. The single grasp refers to a simple grasp of one egg. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the egg and then a grasp of another egg. The simo grasp refers to the simultaneous grasping of two eggs at a time in the same hand. In actual performance, the grasp is not always completely simultaneous. If one egg is a few inches from the other, the first is caught near the little finger and heel of the hand and the hand moved over to grasp the second egg as nearly simultaneously as can be done.

		Skill	Time
MP39	Single (one hand)	.64	22.2
MP41	Consecutive (one hand)	.69	48.9
MP40	Simo (one hand)	.80	33.6
MP42	Single (two hand)	.65	27.8
MP44	Consecutive (two hand)	.71	57.3
MP43	Simo (two hand)	.82	42.6

Skill: In handling eggs, the type of grasp used affects substantially the skill content of the get. The consecutive grasp requires considerably more skill than the single and considerably less than the simo.

Time: The simo grasp requires substantially less time per egg than either of the other two.

Grasps Types Used in Egg Packing: All of the grasps used in packing eggs were made from the bin of an egg grader. These are grasps from a flat surface. The single grasp refers to a simple grasp of one egg. The consecutive grasp refers to a single grasp, followed by a regrasp or palming of the egg, and then a grasp of another egg. The simo two grasp refers to the simultaneous grasping of two eggs at a time in the same hand. In actual performance the grasp is not always completely simultaneous. If one egg is a few inches from the other, the first is caught near the little finger and heel of the hand and the hand moved over to grasp the second egg as nearly simultaneously as can be done. The simo three grasp refers to the simultaneous grasping of three eggs in a hand. Like the simo two, it is not always completely simultaneously done but is as near simultaneous as possible. The two-plus-one grasp refers to a simo grasp of two eggs in a hand, followed by a regrasp and a grasp of a third egg.

		Skill	Time
MP49	Single grasp (two hand)	.66	27.4
MP51	Consecutive grasp (two hand)	.75	55.3
MP50	Simo two grasp (two hand)	.78	39.3
MP53	Simo three grasp (two hand)	.78	61.8
MP54	Two-plus-one grasp (two hand)	.80	81.5

Skill: Grasps of more than one egg per hand are considerably higher in skill requirement than the single grasp. This is very likely due to the fragility factor. The multiple grasps show a fairly narrow range of skill variation.

Time: The simo two grasp requires less time per egg handled, but the simo three is a close second. However, the simo three causes more egg breakage.

Source from Which Egg is Grasped: Eggs were grasped from an egg basket where they are jumbled in depth, from a grader bin where they rest on a flat surface and from the cup of a single-egg scale.

		Skill	Time
MP39	Egg basket (single grasp)	.64	22.2
MP55	Cup of egg scale (single grasp)	.64	22.4
MP42	Egg basket (single grasp)	.65	27.8
MP49	Grader bin (single grasp)	.66	27.4

		Skill	Time
MP44	Egg basket (consecutive grasp)	.71	57.3
MP51	Grader bin (consecutive grasp)	.75	55.3
MP43	Egg basket (simo grasp)	.82	42.6
MP50	Grader bin (simo grasp)	.78	39.3

Skill: There does not appear to be a definite indication that one grasp source requires more skill than another for eggs.

Time: There is an indication that grasps from an egg basket require a little longer than those from an egg bin, but the difference is not great. It is definitely more noticeable in multiple grasps.

Change of Direction in Reach: When eggs were packed in the bottom of the case, a change of direction occurred in the reach. This change of direction does not occur in reach when packing in the top of the case.

		Skill	Time
MP51	No change of direction (top of case)	.75	55.3
MP52	Change of direction (bottom of case)	.74	59.9

Skill: There is no reason to expect the change of direction in reach to cause a change in the skill content of the get. The data confirms that it does not.

Time: One would expect the change of direction to slow down the reach. The data indicates that the reach with change of direction took 8 per cent longer than when no change of direction occurred.

Front Versus Side Reach: A work place can be set up so that reaches are to the front or to the side.

		Skill	Time
MP43	Front reach	.82	42.6
MP46	Side reach	.81	46.7

Skill: Whether the reach was to the front or to the side did not seem to affect skill content significantly.

Method: The side reach and grasp took 10 per cent longer than the front reach and grasp.

The Distance Factor: This series of gets varied only in distance of reach.

		Skill	Time
MP43	12 inches	.82	42.6
MP45	16 inches	.80	46.5
MP47	24 inches	.79	52.3

Skill: There appears to be some indication that less skill is required as the reach distance increases; however, the variation is small. Perhaps the longer reaches give more nearly adequate time for selecting the eggs before the reach terminates.

Method: As distance increases, the performance time also increases but at a much lower rate.

Summary

There appears to be no substantial difference in skill content between one hand and two hand work. Two hand motions require more time per motion but far less time per egg.

Single grasps require the least skill. In order of increasing skill requirements, the grasps are single, consecutive, simo two, simo three and two-plus-one. The simo two requires the least time per egg handled.

Skill content seems to be about the same whether eggs are grasped from a bin or a basket, although grasps from the basket require some more time.

A change of direction which occurs in reach when packing eggs in the bottom of a case does not affect skill requirements but increases time requirements by about 8 per cent.

There was no significant difference in skill content between gets to the front and gets made to the side. The side get required about 10 per cent more time.

In handling eggs there seems to be an inverse relation between skill content and distance but the variation is too small to be of any consequence. The longer distances always require more time but the increase in time is much less than the increase in distance.

Cans

In addition to the different types of grasp, the handling of cans introduces a type of orienting which is most certainly a skill factor. Cans are usually oriented on the shelf so that the labels face outward.

Inventory of Data

Stocking Shelves with Cans - Labels Not Oriented:

		Skill	Time
MP57	One hand single grasp of a 303 can from case. Reach 12"	.62	24.6
MP58	One hand single grasp of a 303 can from case. Reach 18"	.73	24.5
MP59	One hand single grasp of a 303 can from case. Reach 36"	.67	31.6
MP60	Two hand single grasp of a 303 can per hand from case. Reach 18"	.70	31.3
MP61	Two hand simo grasp of two cans per hand from case. Reach 18"	.69	49.1
MP62	Two hand single grasp of a 46-ounce can per hand from case. Reach 18"	.63	34.1
MP63	Two hand single grasp of a 46-ounce can per hand from case. Reach 36"	.66	40.3

Stocking Shelves with Cans - Labels Oriented to Face Customers

MP64	One hand single grasp of one 303 can from case. Reach 18"	.77	25.7
MP65	One hand simo grasp of two 303 cans from case. Reach 18"	.83	40.4
MP66	Two hand transfer grasp of one 303 can from left hand. Reach 18"	.74	36.1
MP67	Two hand single grasp of one 303 can (with 2-faced label) per hand from case. Reach 18"	.72	31.5
MP68	Two hand single grasp of one 303 can per hand from case. Reach 12"	.72	31.0

		Skill	Time
MP69	Two hand single grasp of one 303 can per hand from case. Reach 18"	.74	32.5
MP70	Two hand single grasp of one 303 can per hand from case. Reach 24"	.71	37.9
MP71	Two hand single grasp of one 303 can per hand from case. Side reach 24"	.73	36.9
MP72	Two hand single grasp of one 303 can per hand from case. Reach 36"	.76	40.4
MP73	Two hand grasp of three 303 cans with both hands from case. Reach 18"	.76	43.3
MP74	Two hand simo grasp of two 303 cans per hand from case. Reach 18"	.81	47.5
MP75	Two hand single grasp of one 46-ounce can per hand from case. Reach 18"	.71	36.5

Evaluation of Skill and Method

The following evaluations take into account method variations which affect skill content and those which do not. The evaluations are based on matched pairs or matched series.

One Hand Versus Two Hand: Frequently one observes a person working with only one hand. Methods engineers have sometimes assumed that work output could be doubled by using both hands. These data present a measure of the relation between one hand and two hand work.

		Skill	Time
MP58	One hand (single grasp - no orient)	.73	24.5
MP60	Two hand (single grasp - no orient)	.70	31.3
MP64	One hand (single grasp - orient)	.77	25.7
MP69	Two hand (single grasp - orient)	.74	32.5
MP65	One hand (simo grasp - orient)	.83	40.4
MP74	Two hand (simo grasp - orient)	.81	47.5

Skill: According to the data there is slightly less skill in the two hand motion patterns. The difference is hardly enough to be significant.

Time: The two hand get always required substantially more time than the one hand. However, the time per can is much shorter for the two hand version.

Grasp Types Used in Stocking Shelves with Cans - Labels Not Oriented: The single grasp refers to a simple grasp of one can. The simo grasp refers to the simultaneous grasping of two cans in the same hand.

		Skill	Time
MP60	Single grasp	.70	31.3
MP61	Simo grasp	.69	49.1

Skill: There appears to be no significant difference in the skill requirements of these two grasp types.

Time: The simo grasp required 57 per cent more time but accomplished twice as much work.

Grasps Types Used in Stocking Shelves with Cans - Labels Oriented to Face Customers: The transfer grasp refers to a single grasp of one can from the other hand. The single grasp refers to a simple grasp of one can in a hand from the case. The grasp of three with both hands refers to a grasp of one in each hand plus another sandwiched between. The simo grasp refers to the simultaneous grasping of two cans in the same hand.

		Skill	Time
MP66	Transfer grasp (from other hand)	.74	26.1
MP64	Single grasp	.77	25.7
MP65	Simo grasp	.83	40.4
MP69	Single grasp	.74	32.5
MP73	Grasp of three with both hands	.76	43.3
MP74	Simo grasp	.81	47.5

Skill: The single and transfer grasps require the least amount of skill. Simo grasps require the most.

Time: On a per can basis, the simo grasp requires considerably less time than the others.

No Orienting Versus Orienting: Orienting refers to the turning of labels to a position facing toward the customer; that is, facing outward on the shelf.

		Skill	Time
MP58	No orienting (single grasp)	.73	24.5
MP64	Orienting (single grasp)	.77	25.7
MP62	No orient (single grasp)	.63	34.1
MP75	Orient (single grasp)	.71	36.5
MP61	No orient (simo grasp)	.69	49.1
MP74	Orient (simo grasp)	.81	47.5
MP60	No orient (single grasp)	.70	31.3
MP69	Orient (single grasp)	.74	32.5

Skill: In each case it required more skill to make grasps when orienting was done. Although one thinks of the orienting as occurring at the end of move, it often becomes spread over the entire cycle.

Time: Orienting does not affect time requirements of gets very much.

Front Reach Versus Side Reach: Shelves can be stocked from a position facing the shelf or from a position parallel to the shelf.

		Skill	Time
MP70	Front	.71	37.9
MP71	Side	.73	36.9

Skill: There is little difference shown between the side reaches and front reaches in skill content.

Time: The difference in performance time is quite small and is not believed to be significant.

303 Versus 46-Ounce Can: The 303 can is only about one qurarter the size of the 46-ounce can.

		Skill	Time
MP62	46-ounce can	.63	34.1
MP60	303 can	.70	31.3
MP75	46-ounce can	.71	36.5
MP69	303 can	.74	32.5

Skill: In both cases the 46-ounce pattern showed less skill. There should be less skill in grasping the larger can because the spaces for the fingers to slip into in grasping are larger.

Time: In both cases the larger can required more time. There is sufficient difference in weight that this should be a significant difference.

The Distance Factor: Each of the two series is matched in all characteristics except distance.

		Skill	Time
MP57	12 inches	.62	24.6
MP58	18 inches	.73	24.5
MP59	36 inches	.67	31.6
MP62	18 inches	.63	34.1
MP63	36 inches	.66	40.3
MP68	12 inches	.72	31.0
MP69	18 inches	.74	32.5
MP70	24 inches	.71	37.9

Skill: Distance is not ordinarily a skill factor. These series show no definite relation between distance and skill content.

Time: With one minor exception, as distance increased, performance time increased. However, performance time increased at a much lower rate than distance.

Summary

There was practically no difference in skill content between one and two hand work. The data actually showed a higher skill requirement for one hand work, but the difference was small. The time requirements were always higher for two hand work, but not on a per can basis.

When there was no orienting of labels there was no significant difference between the skill requirements of a single grasp and a simo. However, when orienting was introduced into the cycle, the simo grasp required substantially more skill. The simo grasp required more time to perform but accomplished more per unit of time.

Orienting requires more skill than no orienting. It also adds a little to performance time of get but not very much. Most of the physical turning actually occurs in place.

The side reach showed a slightly higher skill content but hardly enough to be significant. The time requirements were very close to the same.

The 46-ounce can showed less skill requirements than the 303. This is believed to be due to the larger spaces for fingers to enter in making the grasp. The time requirements were higher for the larger can.

There was no definite relationship between distance and skill content. Time requirements increased as distance increased, but at a much lower rate.

Glass Jars

Although glass jars are fragile in a degree, this was not a very important factor. Data is very similar to data for can handling.

Inventory of Data

Stocking Shelves with Jars - Labels Not Oriented:

		Skill	Time
MP76	Two hand single grasp of one pint jar per hand from case. Reach 18"	.64	33.3
MP77	Two hand single grasp of one pint jar per hand from case. Reach 24"	.69	36.1

		Skill	Time
MP78	Two hand single grasp of one pint jar per hand from case. Reach 36"	.70	39.4
MP79	Two hand single grasp of one quart jar per hand from case. Reach 18"	.67	32.3
MP80	Two hand single grasp of one quart jar per hand from case. Reach 24"	.68	36.4
MP81	Two hand single grasp of one quart jar per hand from case. Reach 36"	.67	39.6

Stocking Shelves with Jars - Labels Oriented to Face Customers:

MP82	Two hand single grasp of one pint jar per hand from case. Reach 18"	.75	34.7

Evaluation of Skill and Method

In the above data there is but one skill characteristic, that is the orienting of labels. The distance and size factors are not related to skill.

No Orienting Versus Orienting: Orienting refers to the turning of the jar labels so that they face outward from the shelf.

		Skill	Time
MP76	No orienting	.64	33.3
MP82	Orienting	.75	34.7

Skill: Orienting clearly requires more skill.

Time: More time is required when orienting is present.

The Size Factor: One pint and one quart jars were used. This should have but little influence on the get portion of the cycle.

		Skill	Time
MP76	Pint jar	.64	33.3
MP79	Quart jar	.67	32.3

		Skill	Time
MP77	Pint jar	.69	36.1
MP80	Quart jar	.68	36.4
MP78	Pint jar	.70	39.4
MP81	Quart jar	.67	39.6

Skill: There is no definite relationship between size of jar and skill content of gets.

Time: There is no definite relationship between size of jar and performance time of gets.

The Distance Factor: Within each of the two distance series, distance was the only factor which varied.

		Skill	Time
MP76	18 inches (pint)	.64	33.3
MP77	24 inches (pint)	.69	36.1
MP78	36 inches (pint)	.70	39.4
MP79	18 inches (quart)	.67	32.3
MP80	24 inches (quart)	.68	36.4
MP81	36 inches (quart)	.67	39.6

Skill: Although the skill measure varied within these series somewhat, it did not show a definite relation to distance.

Time: As distance increased, the performance time increased but at a much slower rate.

Summary

Orienting clearly requires more skill than no orienting. Performance time of get was not increased very much by orienting.

Size of jar showed no relationship either to skill content or to performance time.

Distance showed no relationship to skill content. As distance increased, performance time increased but performance time increased at a much lower rate.

Glass Bottles

Although the bottles were fragile in some degree, this did not appear to affect the skill or performance time in handling.

Inventory of Data

Stocking Shelves with Bottles - Labels Not Oriented:

		Skill	Time
MP83	Two hand single grasp of one seven-ounce bottle per hand from case. Reach 18"	.62	28.6
MP84	Two hand single grasp of one seven-ounce bottle per hand from case. Reach 24"	.63	30.8
MP85	Two hand single grasp of one seven-ounce bottle per hand from case. Reach 36"	.67	34.9
MP86	Two hand single grasp of one quart milk bottle per hand from case. Reach 18"	.58	28.6
MP87	Two hand single grasp of one quart milk bottle per hand from case. Reach 24"	.59	32.2
MP88	Two hand single grasp of one quart milk bottle per hand from case. Reach 36"	.66	36.1

Stocking Shelves with Bottles - Labels Oriented to Face Customers:

MP89	Two hand single grasp of one seven-ounce bottle per hand from case. Reach 18"	.70	29.0

Evaluation of Skill and Method

The principal skill factor represented in the above data is the orienting of labels.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward on the shelf.

		Skill	Time
MP83	No orienting	.62	28.6
MP89	Orienting	.70	29.0

Skill: Orienting clearly requires more skill.

Time: The time values are too close together to indicate any significant effect of orienting on get performance time.

The Size Factor: Seven-ounce soft drink bottles and quart milk bottles were used.

		Skill	Time
MP83	Seven-ounce bottle	.62	28.6
MP86	Quart milk bottle	.58	28.6
MP84	Seven-ounce bottle	.63	30.8
MP87	Quart milk bottle	.59	32.2
MP85	Seven-ounce bottle	.67	34.9
MP88	Quart milk bottle	.66	36.1

Skill: The quart milk bottle appears to require less skill. This is probably due to the shape and size of the neck rather than the overall size. The milk bottle neck is shaped better for grasping.

Time: The larger and heavier milk bottle requires slightly more time.

The Distance Factor: Within each of the two distance series, distance was the only factor which varied.

		Skill	Time
MP83	18 inches	.62	28.6
MP84	24 inches	.63	30.8
MP85	36 inches	.67	34.9

		Skill	Time
MP86	18 inches	.58	28.6
MP87	24 inches	.59	32.2
MP88	36 inches	.66	36.1

Skill: There appears to be a rather definite relationship between distance and skill content.

Time: As distance increased, the performance time increased but at a much lower rate.

Summary

Orienting clearly requires more skill than no orienting. However, orienting appeared to have but little effect on performance time.

The quart size required less skill than the seven-ounce soft drink bottle. This is very likely due to the size and shape of the neck rather than the overall size. The milk bottle neck is better shaped for grasping. The larger and heavier milk bottle required more time, but not much more.

In the case of bottles, there seems to be a positive relationship between distance and skill content. Performance time always increased as distance increased but at a much lower rate.

Bags

The data in this section was taken from the handling of one- and two-pound paper bags and 25-pound burlap bags.

Inventory of Data

Stocking Shelves with Bags - Labels Not Oriented:

		Skill	Time
MP90	Two hand single grasp of a one-pound bag per hand from case. Reach 18"	.61	35.8
MP91	Two hand single grasp of a one-pound bag per hand from case. Reach 24"	.66	37.0

		Skill	Time
MP92	Two hand single grasp of a one-pound bag per hand from case. Reach 36"	.66	40.9
MP93	Two hand single grasp of a two-pound bag per hand from case. Reach 18"	.61	36.5
MP94	Two hand single grasp of a two-pound bag per hand from case. Reach 24"	.63	39.7
MP95	Two hand single grasp of a two-pound bag per hand from case. Reach 36"	.63	44.0

Stocking Shelves with Bags - Labels Oriented to Face Customers:

MP96	Two hand single grasp of a one-pound bag per hand from case. Reach 18"	.73	36.8

Moving Large Bags from Stack to Conveyor:

MP97	Grasp one 25-pound bag with both hands from stack. Reach 24"	.52	33.4

Evaluation of Skill and Method

Orienting is the chief skill factor in the above data.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward from the shelf.

		Skill	Time
MP90	No orienting	.61	35.8
MP96	Orienting	.73	36.8

Skill: Orienting requires substantially more skill.

Time: The difference in time between orienting and not orienting is too small to be of much consequence.

The Weight Factor: One-pound and two-pound paper bags were used.

		Skill	Time
MP90	One pound	.61	35.8
MP93	Two pound	.61	36.5
MP91	One pound	.66	37.0
MP94	Two pound	.63	39.7
MP92	One pound	.66	40.9
MP95	Two pound	.63	44.0

Skill: The one-pound bags show a slightly higher level of skill requirement. This evaluation is believed to be correct. There was a little more difficulty in making the grasp of the smaller bag.

Time: In each case the heavier bag required more time, but only a small percentage more than the lighter bags.

The Distance Factor: Within each of the two distance series, distance was the only factor which varied.

		Skill	Time
MP90	18 inches (one-pound)	.61	35.8
MP91	24 inches (one-pound)	.66	37.0
MP92	36 inches (one-pound)	.66	40.9
MP93	18 inches (two-pound)	.61	36.5
MP94	24 inches (two-pound)	.63	39.7
MP95	36 inches (two-pound)	.63	44.0

Skill: The data indicates that there is some increase in skill as distance increases.

Time: In every case, performance time increased as distance increased but at a much lower rate.

Summary

Orienting clearly requires more skill than no orienting. However, performance time for get was not increased very much by orienting.

The one-pound size showed a slightly higher skill requirement. This is believed to be the result of the smaller grasp area on this bag size. Performance time was slightly higher for the heavier bags.

Skill content appears to rise as distance increases. In every case, performance time increased as distance increased but at a much lower rate.

There were no matched pairs for the motion pattern in which 25-pound bags were handled. However, it will be noted that the grasp of one bag with both hands was substantially lower in skill requirements than any of the other bag grasps.

Boxes

The data in this section was taken from the handling of boxes of the following weights: 1/2 pound, 1 pound, 2 1/2 pound, 5 pound, 10 pound, 25 pound, and 50 pound.

Inventory of Data

Stocking Shelves with Boxes - Labels Not Oriented:

		Skill	Time
MP98	Two hand single grasp of one 1/2 pound box per hand from case. Reach 18"	.61	33.0
MP99	Two hand single grasp of one 1/2 pound box per hand from case. Reach 24"	.61	36.6
MP100	Two hand single grasp of one 1/2 pound box per hand from case. Reach 36"	.66	40.8
MP101	Two hand single grasp of one 1-pound box per hand from case. Reach 18"	.61	32.7
MP102	Two hand single grasp of one 1-pound box per hand from case. Reach 24"	.63	35.1
MP103	Two hand single grasp of one 1-pound box per hand from case. Reach 36"	.66	39.9

		Skill	Time
MP104	Two hand single grasp of one 2 1/2 pound box per hand from case. Reach 18"	.57	32.6
MP105	Two hand single grasp of one 2 1/2 pound box per hand from case. Reach 24"	.63	34.7
MP106	Two hand single grasp of one 2 1/2 pound box per hand from case. Reach 36"	.61	40.8
MP107	Two hand single grasp of one 5-pound box per hand from case. Reach 18"	.61	35.5
MP108	Two hand single grasp of one 5-pound box per hand from case. Reach 24"	.61	40.1
MP109	Two hand single grasp of one 5-pound box per hand from case. Reach 36"	.65	44.4

Stocking Shelves with Boxes - Labels Oriented to Face Customers:

		Skill	Time
MP110	Two hand single grasp of one 1/2 pound box per hand from case. Reach 18"	.77	33.7
MP111	Two hand single grasp of one 1-pound box per hand from case. Reach 18"	.77	33.2
MP112	Two hand single grasp of one 2 1/2 pound box per hand from case. Reach 18"	.74	32.4
MP113	Two hand single grasp of one 5-pound box per hand from case. Reach 18"	.69	39.3

Moving Boxes from Stack to Conveyor:

MP114	Grasp one 10-pound box with both hands from stack. Reach 18"	.54	28.5
MP115	Grasp one 10-pound box with both hands from stack. Reach 24"	.52	30.1
MP116	Grasp one 25-pound box with both hands from stack. Reach 24"	.57	36.3
MP117	Grasp one 25-pound box with both hands from stack. Reach 36"	.56	40.0

		Skill	Time
MP118	Grasp one 25-pound box with both hands from stack. Reach 48"	.59	45.9
MP119	Grasp one 50-pound box with both hands from stack. Reach 24"	.59	38.8

Evaluation of Skill and Method

Orienting is the principal skill factor in the above data.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward from the shelf.

		Skill	Time
MP98	No orient (1/2 pound)	.61	33.0
MP110	Orient (1/2 pound)	.77	33.7
MP101	No orient (1 pound)	.61	32.7
MP111	Orient (1 pound)	.77	33.2
MP104	No orient (2 1/2 pound)	.57	32.6
MP112	Orient (2 1/2 pound)	.74	32.4
MP107	No orient (5 pound)	.61	35.5
MP113	Orient (5 pound)	.69	39.3

Skill: Orienting requires substantially more skill.

Time: The difference in performance time between orienting and not orienting is rather small except for the 5-pound boxes.

The Weight Factor in Stocking Shelves: Within each of the following series the only factor which varied was weight.

		Skill	Time
MP98	1/2 pound (18 inch)	.61	33.0
MP101	1 pound (18 inch)	.61	32.7

		Skill	Time
MP104	2 1/2 pound (18 inch)	.57	32.6
MP107	5 pound (18 inch)	.61	35.5
MP99	1/2 pound (24 inch)	.61	36.6
MP102	1 pound (24 inch)	.63	35.1
MP105	2 1/2 pound (24 inch)	.63	34.7
MP108	5 pound (24 inch)	.61	40.1
MP100	1/2 pound (36 inch)	.66	40.8
MP103	1 pound (36 inch)	.66	39.9
MP106	2 1/2 pound (36 inch)	.61	40.8
MP109	5 pound (36 inch)	.65	44.4
MP110	1/2 pound (18 inch)	.77	33.7
MP111	1 pound (18 inch)	.77	33.2
MP112	2 1/2 pound (18 inch)	.74	32.4
MP113	5 pound (18 inch)	.69	39.3

Skill: There appears to be no definite relation between weight and skill content.

Time: The three smaller weights all seem to be very nearly alike in time requirements. The 5-pound weight definitely requires more time.

The Weight Factor in Moving Boxes from Stack to Conveyor: The only factor in this series which varied was weight.

		Skill	Time
MP115	10 pound	.52	30.1
MP116	25 pound	.57	36.3
MP119	50 pound	.59	38.8

Skill: The data indicates that the two heavier weights require more skill. The 10-pound boxes could be grasped by placing a hand on either side of the box. The two heavier boxes required that the fingers of at least one hand be placed under the box.

Time: In each case performance time increased as weight increased, but at a much lower rate.

The Distance Factor in Stocking Shelves: Within each of these series distance was the only factor which varied.

		Skill	Time
MP98	18 inches (1/2 pound)	.61	33.0
MP99	24 inches (1/2 pound)	.61	36.6
MP100	36 inches (1/2 pound)	.66	40.8
MP101	18 inches (1 pound)	.61	32.7
MP102	24 inches (1 pound)	.63	35.1
MP103	36 inches (1 pound)	.66	39.9
MP104	18 inches (2 1/2 pound)	.57	32.6
MP105	24 inches (2 1/2 pound)	.63	34.7
MP106	36 inches (2 1/2 pound)	.61	40.8
MP107	18 inches (5 pound)	.61	35.5
MP108	24 inches (5 pound)	.61	40.1
MP109	36 inches (5 pound)	.65	44.4

Skill: There is considerable indication that there is some positive relation between distance and skill content.

Time: In each case as distance increased performance time increased but at a much lower rate.

The Distance Factor in Moving Boxes to Conveyor: Within each of these series, distance was the only factor which varied.

		Skill	Time
MP114	18 inches (10 pound)	.54	28.5
MP115	24 inches (10 pound)	.52	30.1

		Skill	Time
MP116	24 inches (25 pound)	.57	36.3
MP117	36 inches (25 pound)	.56	40.0
MP118	48 inches (25 pound)	.59	45.9

Skill: Distance and skill content do not appear to be very definitely related in this operation.

Time: In each case, as distance increased, the performance time also increased, but at a much lower rate.

Summary

Orienting labels clearly requires more skill than not orienting. The difference in performance time between orienting and not orienting was generally quite small.

In stocking shelves, there appeared to be no difference in skill content for the weights represented. There was some indication that grasping the 25- and 50-pound boxes required more than was required for grasping the 10-pound boxes. In each case performance time increased as weight increased but at a lower rate.

In stocking shelves there appeared to be quite a definite relationship between distance and skill content. This was not true for the handling of the heavier boxes when loading the conveyor. In every case, as distance increased, performance time increased but at a much lower rate.

CHAPTER VIII

GET AND PLACE: EVALUATION OF SKILL AND METHOD IN POSITION RELEASES

Place is the combination of move, the motions of orienting and positioning the object moved, and release. Move is the travel portion of the combination and its performance time is governed largely by level of effort of the worker. The motions of orient, position and release are manipulative in nature and they are governed in a larger degree by the level of skill.

In film analysis of place, the move appears to be affected by skill content. If complex orienting or precise positioning occur, the move will be longer than when it ends with nothing more than a simple release. Fundamentally this is because of the overlapping of move and these other motions. In other words, the move is longer because of the nature of the manipulative motions of orienting and positioning. The extra time required to perform the move could be more accurately attributed to the manipulative motions. It is both logical and expedient to attribute the skill content of place to the motions of orient, position, and release.

When a person is performing a very low skill motion pattern at a normal rate of speed, he can voluntarily reduce his performance time to about 50-60 per cent of his normal time with no great difficulty. If a fair degree of skill is required to perform the motion pattern, he cannot reduce his performance time quite as much. As the skill content of the motion pattern increases, the worker becomes increasingly restricted in his application of effort. If he pushes effort to too high a level, he begins to fumble. The restrictions caused by skill are used to provide a measure of the skill content of position-release.

The actual measurement is made by dividing the fast average by the normal average for a particular motion pattern. The closer this quotient is to one, the more skill the particular place has in it. Since orient-position-release is really the skill portion of place, the measure may be interpreted as measuring the skill content of orient-position-release.

Round or Oblong Fruits and Vegetables

Specific work operations are: jumble packing, layer packing and stocking display bins. The last of these is subdivided on the basis of weight. Some comparisons are made between different work operations in order to show the effect of certain factors on skill content.

In almost all cases, variations in skill constitute sufficient changes in method to show a significant change in time requirements. There are other changes in method which bear no certain relation to skill content. Method changes are also evaluated and the measurement of method changes is made in terms of normal performance time.

Inventory of Data

Releases Which Occur in Jumble Packing Fruits and Vegetables, 1/4 to 3/4 Pound in Weight:

		Skill	Time
MP1	One hand single release of one apple. Move 12"	.54	19.2
MP2	One hand single release of one apple. Move 24"	.62	21.3
MP3	One hand single release of one apple. Move 24"	.60	21.5
MP4	One hand single release of one apple. Move 36"	.57	27.1
MP5	Two hand single release of one apple per hand. Move 24"	.64	25.4
MP6	Two hand simo release of two apples per hand. Move 16"	.65	24.1
MP7	Two hand simo release of two apples per hand. Move 24"	.62	26.6
MP8	Two hand simo release of two potatoes per hand. Move 24"	.66	26.9
MP9	Two hand simo release of two lemons per hand. Move 24"	.66	27.3
MP10	Two hand simo release of two apples per hand. Move 24"	.64	27.5
MP11	Two hand simo release of two oranges per hand. Move 24"	.65	28.1
MP12	Two hand simo release of two apples per hand. Move 32"	.65	31.4
MP13	Two hand simo release of two and one half apples per hand. Move 24"	.68	29.2
MP14	Two hand simo release of three apples per hand. Move 24"	.78	26.1

Position-Releases Which Occur in Layer Packing Fruits and Vegetables 1/4 to 3/4 Pound in Weight:

		Skill	Time
MP15	One hand single position-release of one apple (following single grasp from flat surface). Move 24"	.71	29.0
MP16	One hand consecutive position-release of two apples (following simo grasp from flat surface). Move 24"	.78	59.6
MP17	Two hand single position-release of one apple per hand (following a single grasp from flat surface). Move 24"	.73	36.6
MP18	Two hand consecutive position-release of two apples per hand (following simo grasp from flat surface). Move 24"	.75	76.5
MP19	Two hand consecutive position-release of two apples per hand (following simo grasp from flat surface). Move 24"	.78	79.2
MP20	Two hand consecutive position-release of two apples per hand (following simo grasp from flat surface). Bottom of box. Move 24"	.79	87.4
MP21	Two hand consecutive position-release of two apples per hand (following consecutive grasp from flat surface). Move 24"	.80	77.3
MP22	Two hand consecutive position-release of two apples per hand (following simo grasp from a box). Move 24"	.80	91.5
MP23	Two hand consecutive position-release of two apples per hand (following consecutive grasp from box). Move 24"	.78	81.9

Releases Used in Stocking Display Bin from Packing Crate, Weights Approximately One, Two and Three Pounds:

		Skill	Time
MP24	Two hand single release of a one pound grapefruit per hand. Move 18"	.57	32.2
MP25	Two hand single release of a one pound grapefruit per hand. Move 24"	.57	31.3
MP26	Two hand single release of a one pound grapefruit per hand. Move 36"	.56	37.1

		Skill	Time
MP27	Two hand single release of a two pound cabbage per hand. Move 18"	.58	35.8
MP28	Two hand single release of a two pound cabbage per hand. Move 24"	.57	37.7
MP29	Two hand single release of a two pound cabbage per hand. Move 36"	.61	41.5
MP30	Two hand release of one three pound cabbage with both hands. Move 18"	.54	35.1
MP31	Two hand release of one three pound cabbage with both hands. Move 24"	.57	37.7
MP32	Two hand release of one three pound cabbage with both hands. Move 36"	.61	43.3

Evaluation of Method and Skill

The criterion for accuracy of the skill measure is personal judgment. Some skill characteristics are obvious, some are not. The skill measure coincided with personal judgment in most cases where the presence of skill elements were clearly recognized. It seems likely that it did as well on those not identified.

Usually the first motion pattern in a pair or series is, in the project staff's collective judgment, the lower or lowest in skill content. However, there are some instances where there was very little basis for selection.

One Hand Versus Two Hand: Occasionally one will observe a worker using only one hand in performing his work while the other hand is idle. Some methods' engineers have assumed that such workers could double their output by using both hands. The following data, it is believed, gives a close approximation to the true relationship between one hand and two hand work.

		Skill	Time
MP2	One hand (jumble pack)	.62	21.3
MP5	Two hand (jumble pack)	.64	25.4
MP15	One hand (layer pack)	.71	29.0
MP17	Two hand (layer pack)	.73	36.6

		Skill	Time
MP16	One hand (layer pack)	.78	59.6
MP19	Two hand (layer pack)	.78	79.2

Skill: One would expect the two hand versions to require more skill. The data shows them to be very nearly alike.

Time: The two hand releases required more time but not nearly in proportion to the increase in work output.

Release Types Used in Jumble Packing: The single release refers to a simple release of one apple with no apparent positioning. The simo release refers to the simultaneous release of two apples with no apparent positioning. The simo two and one-half release refers to the simultaneous release of five apples from both hands following a pincer grasp. There is no apparent positioning for this release. The simo three release refers to the simultaneous releasing of three apples with no apparent positioning.

		Skill	Time
MP5	Single release	.64	25.4
MP10	Simo release	.64	27.5
MP13	Simo two and one half release	.68	29.2
MP14	Simo three release	.78	26.1

Skill: The single and simo releases show the same skill content. The simo two and one half shows only slightly more. The data show considerably higher skill content in the simo three release. Grasping three apples in one hand extends the fingers and in the subsequent release there is some difficulty in disengaging them.

Time: There was a comparatively narrow spread in performance time for these four types of releases, considering the wide difference in the work performed. The simo two and one half took somewhat longer than the others. The arms must be separated slightly to complete this release. The others can be completed by opening the hand.

Release Types Used in Layer Packing: In layer packing apples, the single position-release refers to orienting a single apple, positioning it in the layer and releasing it. The consecutive position-release starts with two apples in the hand. The first one is oriented, positioned, and released; then the second one is brought from the palm into the fingers, oriented, positioned, and released.

		Skill	Time
MP15	Single position-release	.71	29.0
MP16	Consecutive position-release	.78	59.6
MP17	Single position-release	.73	36.6
MP19	Consecutive position-release	.78	79.2

Skill: One would expect the consecutive position-release to require more skill. The data show that it does by a substantial margin.

Time: The consecutive position-release accomplished twice as much but required more than twice as much time. In the first pair, it required 106 per cent more time; in the second pair, 116 per cent more time.

Following Grasp From Flat Surface Versus Following Grasp From A Box: Position-releases were more difficult when they followed grasps from a filled bin or box than when made from a flat surface, because the fruit could not be positioned in the hand as accurately.

		Skill	Time
MP21	Following a grasp from flat surface	.80	77.3
MP23	Following grasp from box	.78	81.9
MP19	Following grasp from flat surface	.78	79.2
MP22	Following grasp from box	.80	91.5

Skill: One would expect that position-releases following grasps from a filled box would require more skill. The data show no difference.

Time: A consecutive position-release following a consecutive grasp from a filled box took six per cent longer than the same type of position-release following a consecutive grasp from a flat surface. A consecutive position-release following a simo grasp from a box took 15 per cent longer than the same type of position-release following a simo grasp from a flat surface.

Following a Consecutive Grasp Versus Following a Simo Grasp: Position-releases were more difficult when they followed simo grasps than when they followed consecutive grasps because the fruit could not be positioned in the hand as accurately.

		Skill	Time
MP21	Following a consecutive grasp	.80	77.3
MP19	Following a simo grasp	.78	79.2
MP23	Following a consecutive grasp	.78	81.9
MP22	Following a simo grasp	.80	91.5

Skill: One would expect the position-release following a simo grasp to require more skill. The data show no difference.

Time: The position-release following a simo grasp was only two per cent longer than the same type of release following a consecutive grasp when the grasps were made from a flat surface. The position-release following a simo grasp was 12 per cent longer than the same type of position-release following a consecutive grasp when the grasps were made from a filled box or bin.

Top of Crate Versus Bottom of Crate: A sharp change of direction occurs in packing in the bottom of a crate. It does not occur while packing the top layer.

		Skill	Time
MP19	Top of crate	.78	79.2
MP20	Bottom of crate	.79	87.4

Skill: The data indicate very little difference in skill between placing in top of crate and placing in bottom of crate.

Time: The change of direction added 10 per cent to the performance time of the place.

The Weight Factor: The same motion pattern was used in handling one pound grapefruit and two pound cabbage.

		Skill	Time
MP24	One pound grapefruit	.57	32.2
MP27	Two pound cabbage	.58	35.8
MP25	One pound grapefruit	.57	31.3
MP28	Two pound cabbage	.57	37.7

		Skill	Time
MP26	One pound grapefruit	.56	37.1
MP29	Two pound cabbage	.61	41.5

Skill: The data show a very slight tendency for higher skill content in releases of the heavier cabbage.

Time: Places of two pound cabbage were decidedly longer in performance time than places of one pound grapefruit.

The Distance Factor: Each of these series was performed at three different distances in order to measure the effect of distance on performance time.

		Skill	Time
MP1	12 inches (apple)	.54	19.2
MP2	24 inches (apple)	.62	21.3
MP4	36 inches (apple)	.57	27.1
MP6	16 inches (apple)	.65	24.1
MP10	24 inches (apple)	.64	27.5
MP12	32 inches (apple)	.65	31.4

		Skill	Time
MP24	18 inches (1 pound grapefruit)	.57	32.2
MP25	24 inches (1 pound grapefruit)	.57	31.3
MP26	36 inches (1 pound grapefruit)	.56	37.1
MP27	18 inches (2 pound cabbage)	.58	35.8
MP28	24 inches (2 pound cabbage)	.57	37.7
MP29	36 inches (2 pound cabbage)	.61	41.5
MP30	18 inches (3 pound cabbage)	.54	35.1
MP31	24 inches (3 pound cabbage)	.57	37.7
MP32	36 inches (3 pound cabbage)	.61	43.3

Skill: The data show no definite relationship between distance and skill content.

Time: The data show that as distance was increased, the performance time of the place increased but not in the same proportion.

Summary of Skill Evaluations of Release and Position-Release

There are several factors which affect the skill content of a release or position-release. These are (1) number of hands employed; (2) type of release; (3) whether or not orienting is necessary; (4) degree of precision in positioning; (5) type of grasp which it follows; and (6) conditions under which the grasp was made.

In all work, two handed work appears to require more skill than one handed work. In operations having a low level of skill content, however, the difference may be quite small. Any measure of skill thus far developed may not show such small differences.

As the types of release become more complex, their skill content increases. The simple releases, in order of skill content, are: single, simo of two, simo of two and one half following pincer grasp, and simo of three. These all apply to jumble packing or jumble arrangement of fruit or vegetables in a display bin. In layer packing, the consecutive position-release definitely requires more skill than the single position-release.

In layer packing, the factor of orienting is introduced. Orienting refers to the turning of the fruit before it is positioned in the crate. The individual apples are turned so that the cheeks are uniformly in the same position. This turning or orienting definitely adds to the skill content of the motion.

Layer packing also requires a more precise positioning. The more precise the positioning, the greater will be the skill content. Positioning refers to the placing of the individual apples in a precise location in the crate.

There is some indication that position-releases which follow a simo grasp are somewhat harder, or have higher skill content, than when they follow consecutive grasps. In a consecutive grasp, some of the orienting is accomplished in performing the grasp and the grasp is generally more precisely executed than is the simo type.

When fruit was grasped from a filled bin or crate, it required more skill in position-releases which followed than was the case when fruit was grasped from a flat surface. The grasp is done more accurately and uniformly from a flat surface.

Summary of Method Evaluation for Releases and Position-Releases

In almost every instance factors which affect the skill content of a place also constitute method change of sufficient significance to change the performance time. In addition to these, there are a few factors which affect performance time which do not affect the skill content.

Increases in distance are accompanied by increases in performance time but the time increases at a much slower rate than the distance.

Increases in weight are accompanied by increases in performance time but not nearly in the same proportion. A doubling of weight will increase performance time only a small percentage.

A sharp change of direction during the move increases the performance time. Such a changed direction is encountered in packing the bottom layers of a crate.

Bunch Vegetables

There is no factor represented in these motion patterns which is primarily a skill factor.

Inventory of Data

		Skill	Time
MP33	Two hand single release of a one pound artificial bunch vegetable per hand. Move 18"	.61	40.1
MP34	Two hand single release of a one pound celery per hand. Move 24"	.60	36.7
MP35	Two hand single release of a one pound celery per hand. Move 36"	.60	40.4
MP36	Two hand single release of a two pound celery per hand. Move 18"	.58	37.6
MP37	Two hand single release of a two pound celery per hand. Move 24"	.62	39.7
MP38	Two hand single release of a two pound celery per hand. Move 36"	.63	44.3

The Weight Factor: The same motion pattern is used in both the one and two pound celery handling.

		Skill	Time
MP34	One pound celery	.60	36.7
MP37	Two pound celery	.62	39.7
MP35	One pound celery	.60	40.4
MP38	Two pound celery	.63	44.3

Skill: The two pound celery showed a slight increase in skill requirements over the one pound.

Time: The two pound celery showed a decided increase in time requirements over the one pound.

The Distance Factor: Each of the two series is matched in all characteristics but distance.

		Skill	Time
MP34	24 inches (one pound)	.60	36.7
MP35	36 inches (one pound)	.60	40.4
MP36	18 inches (two pound)	.58	37.6
MP37	24 inches (two pound)	.62	39.7
MP38	36 inches (two pound)	.63	44.3

Skill: The one pound series shows no effect of distance on skill content. The two pound series shows a definite increase. It seems likely that skill requirements do increase some as distance increases.

Time: Time requirements increase each time distance is increased but at a much lower rate.

Eggs

The additional factor of fragility is introduced in egg handling. It is quite apparent in observing the work that fragility is of considerable significance.

Inventory of Data

Position-Releases Which Occur in Loading Egg Grader:

		Skill	Time
MP39	One hand single position-release of one egg on grader track. Move 12"	.62	22.0
MP40	One hand consecutive position-release of two eggs per hand on grader track. (Following simo grasp) Move 12"	.68	52.5
MP41	One hand consecutive position-release of two eggs per hand on grader track. (Following consecutive grasp) Move 12"	.63	49.2
MP42	Two hand single position-release of one egg per hand on grader track. Move 12"	.62	26.2
MP43	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Move 12"	.68	64.2
MP44	Two hand consecutive position-release of two eggs per hand on grader track (following consecutive grasp). Move 12"	.65	56.7
MP45	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Move 16"	.68	68.1
MP46	Two hand consecutive position-release of two eggs per hand on grader track (following simo grasp). Side move 12"	.73	68.2
MP47	Two hand consecutive position-release of two eggs per hand on grader track. (Following simo grasp) Move 24"	.72	68.5

Position-Releases Which Occur in Packing Eggs:

MP48	One hand single position-release of one egg. Move 12"	.65	22.6
MP49	Two hand single position-release of one egg per hand in case. Move 12"	.64	26.6
MP50	Two hand consecutive position-release of two eggs per hand in case (following simo grasp). Move 12"	.70	61.8

		Skill	Time
MP51	Two hand consecutive position-release of two eggs per hand in case (following consecutive grasp). Move 12"	.72	49.2
MP52	Two hand consecutive position-release of two eggs per hand in bottom of case (following consecutive grasp). Move 12"	.72	56.7
MP53	Two hand consecutive position-release of three eggs per hand in case (following simo three grasp). Move 12"	.71	98.6
MP54	Two hand consecutive position-release of three eggs per hand in case (following two plus one grasp). Move 12"	.74	81.6

Weighing Eggs on a Single Egg Scale - One Hand Operation Only:

MP55	One hand single transfer of an egg into other hand. Move 12"	.63	19.3
MP56	One hand single position-release of an egg on cup of egg scale. Move 12"	.62	23.6

Evaluation of Skill and Method

The following evaluations take into account method variations which affect skill content and those which do not. The evaluations are based on matched pairs and matched series.

One Hand Versus Two Hand Work: Frequently one observes a person working with only one hand. Methods engineers have assumed that work output could be doubled by using both hands. These data present a measure of the relation between one hand and two hand work.

		Skill	Time
MP39	One Hand (grading)	.62	22.0
MP42	Two Hand (grading)	.62	26.2
MP41	One Hand (grading)	.63	49.2
MP44	Two Hand (grading)	.65	56.7

		Skill	Time
MP40	One Hand (grading)	.68	52.5
MP43	Two Hand (grading)	.68	64.2
MP48	One Hand (packing)	.65	22.6
MP49	Two Hand (packing)	.64	26.6

Skill: These data give no indication that two hand work requires any more skill than one hand work.

Time: In every case, the two hand operation required more time per place. The increase in time requirements was not nearly in proportion to the increase in work accomplished.

Types of Position-Release Used in Grading: The single position-release refers to the positioning of one egg on the grader track so that the long axis of the egg lays across the two sides of the track, and then releasing it. The consecutive position-release refers to a single position-release followed by a regrasping of another egg from the palm to the fingers, and a position-release of the second egg. The difficulty of performing the consecutive position-release varies depending on whether it follows a consecutive or simo grasp. Both versions are shown.

		Skill	Time
MP39	Single position-release	.62	22.0
MP41	Consecutive position-release (after consecutive grasp)	.63	49.2
MP40	Consecutive position-release (after simo grasp)	.68	52.5
MP42	Single position-release	.62	26.2
MP44	Consecutive position-release (after consecutive grasp)	.65	56.7
MP43	Consecutive position-release (after simo grasp)	.68	64.2

Skill: The consecutive position-release requires more skill than the single position release, but the spread between them is considerably wider if the consecutive position-release follows a simo grasp. In performing the simo grasp, the two eggs are grasped in whatever manner

they happen to lie; whereas, in the consecutive grasp, they can be positioned in the hand quite uniformly. This accounts for the effect of the grasp type upon the subsequent position-release.

Time: The performance time for the consecutive position-release is more than double that of the single position-release. The difference is even greater when the consecutive position-release follows a simo grasp.

Type of Position-Release Used in Packing: The single position-release refers to the positioning of a single egg over a cell in an egg filler with the pointed end of the egg pointing downward and releasing it. The consecutive two position-release refers to one single position-release followed by another for a second egg from the same hand. The consecutive three position-release refers to three single position-releases performed consecutively with three eggs all from the same hand. It follows a simo three or two plus one grasp.

		Skill	Time
MP49	Single position-release	.64	26.6
MP51	Consecutive two position-release (after consecutive grasp)	.72	49.2
MP50	Consecutive two position-release (after simo grasp)	.70	61.8
MP54	Consecutive three position-release (after two plus one grasp)	.74	81.6
MP53	Consecutive three position-release (after simo three grasp)	.71	98.6

Skill: The consecutive position-releases require more skill than the single but it does not seem to matter whether it is a two or three egg release. The type of grasp which the consecutive releases follow made very little difference in skill content.

Time: The consecutive two position-release requires more than double the time of a single, but the consecutive three position-release was even worse on a per egg basis. The consecutive position-releases always required substantially more time when they followed simo grasps.

Change of Direction in Move: When eggs are packed in the bottom of the case, a change of direction occurs in the move. This change of direction does not occur when packing in the top of the case.

		Skill	Time
MP51	No change of direction (top of case)	.72	49.2
MP52	Change of direction (bottom of case)	.72	56.7

Skill: The data indicate no change at all in skill content when change of direction is introduced.

Time: One would expect the change of direction to slow down the move. The data showed that change of direction took 15 per cent longer than when no change of direction occurred.

Front Versus Side Move: A work place can be set up so that moves are are to the front or to the side.

		Skill	Time
MP43	Front move	.68	64.2
MP46	Side move	.73	68.2

Skill: Apparently somewhat more skill is required in making the side move. This effect is probably due to the greater control required in terminating the move when the track is approached from the side. When the track is approached from the front, the move is in line with the track and the egg may be placed anywhere along several inches of the track. However, when the track is approached from the side, the move is at a right angle to the track, and, consequently, the move must terminate at a more precise point. The egg must be placed on the track and the track is only one and one half inches wide.

Time: The side move and position-release took six per cent longer than the front move and position-release.

The Distance Factor: This series of places varied only in the distance of move.

		Skill	Time
MP43	12 inches	.68	64.2
MP45	16 inches	.68	68.1
MP47	24 inches	.72	68.5

Skill: There is some indication that the longer move requires more skill.

Time: Performance time increased as distance increased but at a much lower rate.

Summary

There appears to be no substantial difference in skill content between one hand and two hand work. Two hand places require more time per place but far less time per egg.

The single position-release requires the least skill. The consecutive two position-release requires considerably more skill and the difference is even wider when it follows a simo grasp. The consecutive three position-release is very little different in skill requirements from the consecutive two. The time requirements increased in order of the number of eggs handled. Time requirements for position-release were considerably greater when the position-release followed a simo grasp.

A change of direction which occurs in move when packing in the bottom of the case does not affect skill requirements but increases the time requirements by 15 per cent.

Somewhat more skill and more time is required in making places to the side rather than to the front.

There is a slight indication that more skill is required for the longer distances. Time requirements increase as distance increases but at a much lower rate.

Cans

In addition to the different types of positioning, the handling of cans introduces a type of orienting which is most certainly a skill factor. Cans are usually oriented on the shelf so that the labels face outward.

Inventory of Data

Stocking Shelves with Cans - Labels not Oriented:

		Skill	Time
MP57	One hand single position-release of one 303 can on shelf. Move 12"	.54	32.9
MP58	One hand single position-release of one 303 can on shelf. Move 18"	.64	32.1
MP59	One hand single position-release of one 303 can on shelf. Move 36"	.62	45.1

		Skill	Time
MP60	Two hand single position-release of one 303 can per hand on shelf. Move 18"	.65	39.1
MP61	Two hand simo position-release of two 303 cans per hand on shelf. Move 18"	.61	57.4
MP62	Two hand single position-release of one 46-ounce can per hand on shelf. Move 18"	.60	44.2
MP63	Two hand single position-release of one 46-ounce can per hand on shelf. Move 36"	.64	59.0

Stocking Shelves with Cans - Labels Oriented to Face Customers:

		Skill	Time
MP64	One hand single position-release of a 303 can on shelf. Move 18"	.66	46.4
MP65	One hand consecutive position-release of two 303 cans on shelf. Move 18"	.70	98.0
MP66	Two hand single position-release of one 303 can on shelf (after transfer grasp from other hand). Move 18"	.70	33.8
MP67	Two hand single position-release of a 303 can (with 2-faced label) per hand on shelf. Move 18"	.64	46.2
MP68	Two hand single position-release of one 303 can per hand on shelf. Move 12"	.67	59.2
MP69	Two hand single position-release of one 303 can per hand on shelf. Move 18"	.70	61.2
MP70	Two hand single position-release of one 303 can per hand on shelf. Move 24"	.73	61.9
MP71	Two hand single position-release of one 303 can per hand on shelf. Side move 24"	.74	64.5
MP72	Two hand single position-release of one 303 can per hand on shelf. Move 36"	.76	69.8
MP73	Two hand position-release of three 303 cans with both hands on shelf. Move 18"	.79	101.2
MP74	Two hand consecutive position-release of two 303 cans per hand on shelf. Move 18"	.79	135.5
MP75	Two hand single position-release of one 46-ounce can per hand on shelf. Move 18"	.74	70.1

Evaluation of Skill and Method

The following evaluations take into account method variations which affect skill content and those which do not. The evaluations are based on matched pairs or matched series.

One Hand Versus Two Hand: Frequently one observes a person working with only one hand. Methods engineers have some times assumed that work output could be doubled by using both hands. These data present a measure of the relation between one hand and two hand work.

		Skill	Time
MP58	One hand (single position-release, no orient)	.64	32.9
MP60	Two hand (single position-release, no orient)	.65	39.1
MP64	One hand (single position-release, orient)	.66	46.4
MP69	Two hand (single position-release, orient)	.70	61.2
MP65	One hand (consecutive position-release, orient)	.70	98.0
MP74	Two hand (consecutive position-release, orient)	.79	135.5

Skill: There is not much difference between one hand and two hand work when no orienting takes place. There is a substantial amount more skill required for two hand work when orienting is done, and the spread of difference between one and two hand work is even wider when the consecutive position-release is used.

Time: The two hand work always requires more total time but considerably less time per can.

Position-Releases Used to Stock Shelves with Cans - Labels not Oriented: The single position-release refers to the positioning of a can in its place on the shelf and the releasing of the can. The simo position-release refers to positioning two cans per hand simultaneously on the shelf and releasing them.

		Skill	Time
MP60	Single position-release	.65	39.1
MP61	Simo position-release	.61	57.4

Skill: The simo position-release required the lesser amount of skill. If this result is significant, it probably is due to the fact that an entire line of 4 cans are placed on the shelf at once in the simo position-release.

Time: The simo position-release required 47 per cent more time but accomplished twice as much work because 2 eggs instead of one were moved.

Position-Releases Used to Stock Shelves with Cans - Labels Oriented to Face Customer: The single position-release after transfer grasp refers to the orienting of one can with the right hand, and the positioning and release of that can. The single position-release is the same except that the grasp is made from a case. The position-release three with both hands refers to a single position-release of one can per hand followed by a position-release of the third, usually with the right hand. The consecutive position-release refers to a single position-release followed by a position-release of a second can from the same hand.

		Skill	Time
MP66	Single position-release (after transfer grasp)	.70	33.8
MP64	Single position-release (after single grasp)	.66	46.4
MP65	Consecutive position-release	.70	98.0
MP69	Single position-release	.70	61.2
MP73	Position-release three with both hands	.79	101.2
MP74	Consecutive position-release	.79	135.5

Skill: The single position-releases require the least skill. The consecutive position-releases require more, particularly when it is a two-hand operation such as in the second series above. Where both hands are orienting and positioning simultaneously, there are eye requirements for both hands. Acquisition of skill can reduce the required eye time. When a worker has low skill, he will orient the can in one hand, then turn to the other because he cannot direct them simultaneously.

Time: The time requirements increase as the number of cans handled increases, but in a lower proportion.

No Orienting Versus Orienting: Orienting refers to the turning of labels to a position facing toward the customer; that is, facing outward on the shelf.

		Skill	Time
MP58	No orienting (one hand)	.64	32.1
MP64	Orienting (one hand)	.66	46.4
MP62	No orienting (two hand)	.60	44.2
MP75	Orienting (two hand)	.74	70.1
MP60	No orienting (two hand)	.65	39.1
MP69	Orienting (two hand)	.70	61.2
MP61	No orienting (two hand)	.61	57.4
MP74	Orienting (two hand)	.79	135.5

Skill: In each case the orienting required more skill than no orienting. The skill requirements for orienting were very much greater when the work was a two-hand operation.

Time: Orienting increased the time requirements in all cases but more than doubled time requirements when the consecutive position-release was used (see last pair above).

Front Reach Versus Side Reach: Shelves can be stocked from a position facing the shelf or from a position parallel to the shelf.

		Skill	Time
MP70	Front	.73	61.9
MP71	Side	.74	64.5

Skill: The data indicate too small a difference in skill requirements to be of any consequence.

Time: The side place took four per cent more time than the front place.

303 Can Versus 46 Ounce Can: The 303 can is only about one-quarter the size of the 46 ounce can.

		Skill	Time
MP60	303 can (no orient)	.65	39.1
MP62	46 ounce can (no orient)	.60	44.2

		Skill	Time
MP69	303 can (orient)	.70	61.2
MP75	46 ounce can (orient)	.74	70.1

Skill: The 46 ounce can required less skill to handle when it was not oriented but required more when it had to be oriented. The extra weight and larger diameter of the 46 ounce can make orienting particularly difficult.

Time: In each case the 46 ounce can required more time to handle.

The Distance Factor: Each of the three series is matched in all characteristics except distance.

		Skill	Time
MP57	12 inches (no orient)	.54	32.9
MP58	18 inches (no orient)	.64	32.1
MP59	36 inches (no orient)	.62	45.1
MP62	18 inches (no orient)	.60	44.2
MP63	36 inches (no orient)	.64	59.0
MP68	12 inches (orient)	.67	59.2
MP69	18 inches (orient)	.70	61.2
MP70	24 inches (orient)	.73	61.9

Skill: There is some evidence that skill requirements increase as distance increases, even when no orienting is required. When orienting is required, the effect of distance on skill content is quite pronounced.

Time: As distance increases, performance time increases but at a lower rate.

Summary

There is not much difference between one and two hand work when no orienting takes place. When orienting is required, the two hand work definitely requires more skill. Two hand work always requires more time per motion but less time per can.

When no orienting is required, the simo position-release takes no more skill than the single, but takes considerably more time. When orienting is required, the consecutive position-releases require more skill than the single position-release. This difference is definitely greater for two hand operations. The time requirements increase as number of cans handled increases.

Orienting required more skill than no orienting, but the difference was much greater for two hand work. Orienting necessitates the use of the eyes, and two hand orienting presents a conflict for the use of the eyes. Orienting increased the time requirements but more than doubled time requirements when the consecutive position release was used. This was because of the awkwardness of manipulating one can while holding another can in the same hand.

The side place required about the same amount of skill as the front place, and only four per cent more time.

The 46 ounce can required less skill to handle when it was not oriented but more when it had to be oriented. The extra weight and larger diameter of the 46 ounce can made it particularly difficult to orient. In each case the 46 ounce can required more time to handle, but it only required 13 per cent more time without orienting, whereas it required 52 per cent more when orienting was necessary.

Glass Jars

Although glass jars are fragile in a degree, this was not a very important factor in either skill requirements or performance time. Data is very similar to data for can handling.

Inventory of Data

Stocking Shelves with Jars - Labels Not Oriented:

		Skill	Time
MP76	Two hand single position-release of one pint jar per hand on shelf. Move 18"	.56	40.0
MP77	Two hand single position-release of one pint jar per hand on shelf. Move 24"	.59	41.7
MP78	Two hand single position-release of one pint jar per hand on shelf. Move 36"	.63	49.3
MP79	Two hand single position-release of one quart jar per hand on shelf. Move 18"	.64	46.1

		Skill	Time
MP80	Two hand single position-release of one quart jar per hand on shelf. Move 24"	.64	49.1
MP81	Two hand single position-release of one quart jar per hand on shelf. Move 36"	.66	58.5

Stocking Shelves with Jars - Labels Oriented to Face Customers:

MP82	Two hand single position-release of one pint jar per hand on shelf. Move 18"	.69	62.4

Evaluation of Skill and Method

The principal skill factor in the above data is orienting.

No Orienting Versus Orienting: Orienting refers to the turning of the jar labels so that they face outward on the shelf.

		Skill	Time
MP76	No orienting	.56	40.0
MP82	Orienting	.69	62.4

Skill: Orienting clearly requires more skill.

Time: The place requires substantially more time when orienting is done.

The Size Factor: One pint and one quart jars were used.

		Skill	Time
MP76	Pint jar (18 inches)	.56	40.0
MP79	Quart jar (18 inches)	.64	46.1
MP77	Pint jar (24 inches)	.59	41.7
MP80	Quart jar (24 inches)	.64	49.1
MP78	Pint jar (36 inches)	.63	49.3
MP81	Quart jar (36 inches)	.66	58.5

Skill: The quart jars definitely required more skill in place.

Time: In each case, the quart jars required considerably more time than the pints.

The Distance Factor: Within each of the two series, distance was the only factor which varied.

		Skill	Time
MP76	18 inches (pint)	.56	40.0
MP77	24 inches (pint)	.59	41.7
MP78	36 inches (pint)	.63	49.3
MP79	18 inches (quart)	.64	46.1
MP80	24 inches (quart)	.64	49.1
MP81	36 inches (quart)	.66	58.5

Skill: The data definitely indicates that skill content increases as distance increases.

Time: As distance increases, time requirements increase but at a much slower rate.

Summary

Orienting clearly requires more skill than no orienting. Orienting also requires substantially more time.

The quart jar requires more skill and more time than the pints.

Both skill content and performance time increased as distance increased.

Glass Bottles

Although the bottles were fragile in a degree, this appeared to have little, if any, effect on skill or performance time.

Inventory of Data

Stocking Shelves with Bottles - Labels Not Oriented:

		Skill	Time
MP83	Two hand single position-release of one seven-ounce bottle per hand on shelf. Move 18"	.59	45.9
MP84	Two hand single position-release of one seven-ounce bottle per hand on shelf. Move 24"	.60	47.8
MP85	Two hand single position-release of one seven-ounce bottle per hand on shelf. Move 36"	.66	54.7
MP86	Two hand single position-release of one quart milk bottle per hand on shelf. Move 18"	.61	51.3
MP87	Two hand single position-release of one quart milk bottle per hand on shelf. Move 24"	.62	54.5
MP88	Two hand single position-release of one quart milk bottle per hand on shelf. Move 36"	.67	64.1

Stocking Shelves with Bottles - Labels Oriented to Face Customers:

MP89	Two hand single position-release of one seven-ounce bottle per hand on shelf. Move 18"	.72	57.8

Evaluation of Skill and Method

The principal skill factor represented in the above data is orienting.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward on the shelf.

		Skill	Time
MP83	No orienting	.59	45.9
MP89	Orienting	.72	57.8

Skill: Orienting clearly requires more skill.

Time: Orienting requires substantially more time than not orienting.

The Size Factor: Seven-ounce soft drink bottles and quart milk bottles were used.

		Skill	Time
MP83	Seven-ounce bottle (18 inches)	.59	45.9
MP86	Quart milk bottle (18 inches)	.61	51.3
MP84	Seven-ounce bottle (24 inches)	.60	47.8
MP87	Quart milk bottle (24 inches)	.62	54.5
MP85	Seven-ounce bottle (36 inches)	.66	54.7
MP88	Quart milk bottle (36 inches)	.67	64.1

Skill: The data consistently show a very slight increase in skill content when the quart milk bottles were handled, but the difference is so slight as to be negligible.

Time: Substantially more time is required for handling the quart milk bottles than seven-ounce bottles.

The Distance Factor: Within each of the two distance series, distance was the only factor which varied.

		Skill	Time
MP83	18 inches (seven-ounce bottle)	.59	45.9
MP84	24 inches (seven-ounce bottle)	.60	47.8
MP85	36 inches (seven-ounce bottle)	.66	54.7
MP86	18 inches (quart milk bottle)	.61	51.3
MP87	24 inches (quart milk bottle)	.62	54.5
MP88	36 inches (quart milk bottle)	.67	64.1

Skill: There appears to be a rather definite relationship between distance and skill content.

Time: As distance increased, performance time increased but at a much lower rate.

Summary

Orienting very clearly requires both more skill and more time than no orienting.

There was practically no difference in skill content due to size but performance time was definitely longer for the larger size bottle.

Both skill and performance time increased as distance increased but at a much lower rate.

Bags

The data in this section was taken from the handling of one and two pound paper bags and 25 pound burlap bags.

Inventory of Data

Stocking Shelves with Bags - Labels Not Oriented:

		Skill	Time
MP90	Two hand single position-release of one pound bag per hand on shelf. Move 18"	.59	37.2
MP91	Two hand single position-release of one pound bag per hand on shelf. Move 24"	.62	39.5
MP92	Two hand single position-release of one pound bag per hand on shelf. Move 36"	.64	46.8
MP93	Two hand single position-release of two pound bag per hand on shelf. Move 18"	.57	36.9
MP94	Two hand single position-release of two pound bag per hand on shelf. Move 24"	.57	40.4
MP95	Two hand single position-release of two pound bag per hand on shelf. Move 36"	.60	49.9

Stocking Shelves with Bags - Labels Oriented to Face Customers:

		Skill	Time
MP96	Two hand single position-release of one pound bag per hand on shelf. Move 18"	.69	51.0

Moving Large Bags from Stack to Conveyor:

		Skill	Time
MP97	Release one 25-pound bag with both hands on conveyor. Move 24"	.57	36.1

Evaluation of Skill and Method

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward from the shelf.

		Skill	Time
MP90	No orienting	.59	37.2
MP96	Orienting	.69	51.0

Skill: Orienting requires substantially more skill than no orienting.

Time: Oriening also requires substantially more time than no orienting.

The Weight Factor: One pound and two pound paper bags were used.

		Skill	Time
MP90	One pound (18 inches)	.59	37.2
MP93	Two pound (18 inches)	.57	36.9
MP91	One pound (24 inches)	.62	39.5
MP94	Two pound (24 inches)	.57	40.4
MP92	One pound (36 inches)	.64	46.8
MP95	Two pound (36 inches)	.60	49.9

Skill: The data indicate that somewhat more skill was required in handling the smaller bags. These bags were more troublesome in positioning. They were so small in diameter that they frequently fell over unless positioned rather precisely.

Time: Time requirements are not greatly different between the one and two pound weights, but the larger bag averaged taking just a little longer.

The Distance Factor: Within each of these two series of data, distance was the only factor which varied.

		Skill	Time
MP90	18 inches (one pound)	.59	37.2
MP91	24 inches (one pound)	.62	39.5
MP92	36 inches (one pound)	.64	46.8
MP93	18 inches (two pound)	.57	36.9
MP94	24 inches (two pound)	.57	40.4
MP95	36 inches (two pound)	.60	49.9

Skill: The data indicate that skill content increases as distance increases.

Time: As distance increases, performance time increases but at a much lower rate.

Summary

Orienting requires substantially more skill and more time than no orienting.

The data indicated more skill was needed for the one pound bag. This was not due to weight but to the smaller diameter of these bags. The small diameter required a more precise positioning so that they would not fall over. There was little difference between one and two pound bags in performance time.

Both skill content and performance time increased as distance increased but at a much lower rate.

There was no matched pair for the motion pattern in which the 25 pound bag was used. However, it was noted that the place of one 25 pound bag with both hands required very little skill.

Boxes

The data in this section was taken from the handling of boxes of the following weights: 1/2 pound, 1 pound, 2 1/2 pounds, 5 pounds, 10 pounds, 25 pounds and 50 pounds.

Inventory of Data

Stocking Shelves with Boxes - Labels not Oriented:

		Skill	Time
MP98	Two hand single position-release of one 1/2 pound box per hand on shelf. Move 18"	.52	38.5
MP99	Two hand single position-release of one 1/2 pound box per hand on shelf. Move 24"	.55	40.2
MP100	Two hand single position-release of one 1/2 pound box per hand on shelf. Move 36"	.58	47.9
MP101	Two hand single position-release of one 1-pound box per hand on shelf. Move 18"	.54	40.5
MP102	Two hand single position-release of one 1-pound box per hand on shelf. Move 24"	.56	43.1
MP103	Two hand single position-release of one 1-pound box per hand on shelf. Move 36"	.60	52.9
MP104	Two hand single position-release of one 2 1/2 pound box per hand on shelf. Move 18"	.52	42.0
MP105	Two hand single position-release of one 2 1/2 pound box per hand on shelf. Move 24"	.55	45.6
MP106	Two hand single position-release of one 2 1/2 pound box per hand on shelf. Move 36"	.60	54.4
MP107	Two hand single position-release of one 5 pound box per hand on shelf. Move 18"	.56	48.6
MP108	Two hand single position-release of one 5 pound box per hand on shelf. Move 24"	.56	54.9
MP109	Two hand single position-release of one 5 pound box per hand on shelf. Move 36"	.61	65.7

Stocking Shelves with Boxes - Labels Oriented to Face Customers:

		Skill	Time
MP110	Two hand single position-release of one 1/2 pound box per hand on shelf. Move 18"	.69	47.3
MP111	Two hand single position-release of one 1-pound box per hand on shelf. Move 18"	.71	50.8
MP112	Two hand single position-release of one 2 1/2 pound box per hand on shelf. Move 18"	.70	53.3
MP113	Two hand single position-release of one 5 pound box per hand on shelf. Move 18"	.69	66.8

Moving Boxes from Stack to Conveyor:

MP114	Release one 10-pound box with both hands on conveyor. Move 18"	.55	30.4
MP115	Release one 10-pound box with both hands on conveyor. Move 24"	.58	31.7
MP116	Release one 25-pound box with both hands on conveyor. Move 36"	.60	42.0
MP117	Release one 25-pound box with both hands on conveyor. Move 36"	.62	44.7
MP118	Release one 25-pound box with both hands on conveyor. Move 48"	.66	49.1
MP119	Release one 50-pound box with both hands on conveyor. Move 24"	.62	49.9

Evaluation of Skill and Method

Orienting is the principal skill factor in the above data.

No Orienting Versus Orienting: Orienting refers to the turning of labels so that they face outward from the shelf.

		Skill	Time
MP98	No orient (1/2 pound)	.52	38.5
MP110	Orient (1/2 pound)	.69	47.3

		Skill	Time
MP101	No orient (1 pound)	.54	40.5
MP111	Orient (1 pound)	.71	50.8
MP104	No orient (2 1/2 pound)	.52	42.0
MP112	Orient (2 1/2 pound)	.70	53.3
MP107	No orient (5 pound)	.56	48.6
MP113	Orient (5 pound)	.69	66.8

Skill: Orienting requires substantially more skill.

Time: The time for orienting is substantial for all weights, but it increases as weight increases. The manipulation of a 5-pound box is somewhat more difficult to do than with the lighter boxes.

The Weight Factor in Stocking Shelves: Within each of the following series, the only factor which varied was weight.

		Skill	Time
MP98	1/2 pound (18 inches, no orient)	.52	38.5
MP101	1 pound (18 inches, no orient)	.54	40.5
MP104	2 1/2 pound (18 inches, no orient)	.52	42.0
MP107	5 pound (18 inches, no orient)	.56	48.6
MP99	1/2 pound (24 inches, no orient)	.55	40.2
MP102	1 pound (24 inches, no orient)	.56	43.1
MP105	2 1/2 pound (24 inches, no orient)	.55	45.6
MP108	5 pound (24 inches, no orient)	.56	54.9
MP100	1/2 pound (36 inches, no orient)	.58	47.9
MP103	1 pound (36 inches, no orient)	.60	52.9
MP106	2 1/2 pound (36 inches, no orient)	.60	54.4
MP109	5 pound (36 inches, no orient)	.61	65.7

		Skill	Time
MP110	1/2 pound (18 inches, orient)	.69	47.3
MP111	1 pound (18 inches, orient)	.71	50.8
MP112	2 1/2 pound (18 inches, orient)	.70	53.3
MP113	5 pound (18 inches, orient)	.69	66.8

Skill: There appears to be very little if any relation between weight and skill content.

Time: As weight increased, the performance time increased. The rate of increase appears to be associated with distance. The effect of increasing weight was greater at longer distances. It was also associated with orienting. The effect of weight was greater when orienting was done.

The Weight Factor in Moving Boxes from Stack to Conveyor: The only factor in this series which varied was weight.

		Skill	Time
MP115	10 pound	.58	31.7
MP116	25 pound	.60	42.0
MP119	50 pound	.62	49.9

Skill: The data indicates that there is a slight increase in skill content as weight increases. However, all of these releases were very low in skill requirements and the difference was negligible.

Time: As weight increased, performance time increased considerably.

The Distance Factor in Stocking Shelves: Within each of these series, distance was the only factor which varied.

		Skill	Time
MP98	18 inches (1/2 pound)	.52	38.5
MP99	24 inches (1/2 pound)	.55	40.2
MP100	36 inches (1/2 pound)	.58	47.9

		Skill	Time
MP101	18 inches (1 pound)	.54	40.5
MP102	24 inches (1 pound)	.56	43.1
MP103	36 inches (1 pound)	.60	52.9
MP104	18 inches (2 1/2 pound)	.52	42.0
MP105	24 inches (2 1/2 pound)	.55	45.6
MP106	36 inches (2 1/2 pound)	.60	54.4
MP107	18 inches (5 pound)	.56	48.6
MP108	24 inches (5 pound)	.56	54.9
MP109	36 inches (5 pound)	.61	65.7

Skill: Very definitely, the skill content increased as distance increased.

Time: In each case, as distance increased the performance time increased but at a lower rate.

The Distance Factor in Moving Boxes from Stack to Conveyor: Within each of these series, distance was the only factor which varied.

		Skill	Time
MP114	18 inches (10 pound)	.55	30.4
MP115	24 inches (10 pound)	.58	31.7
MP116	24 inches (25 pound)	.60	42.0
MP117	36 inches (25 pound)	.62	44.7
MP118	48 inches (25 pound)	.66	49.1

Skill: Skill content increased as distance increased, but the rate of increase was rather slight.

Time: As distance increased, performance time increased but at a much lower rate.

Summary

Orienting requires substantially more skill and more time.

In stocking shelves, there appeared to be very little effect of weight on skill content. There was a decided effect on performance time and the influence of weight was even greater at the longer distances. The effect of weight was also greater when orienting was done.

When moving boxes from stack to conveyor, there appeared to be a slight increase in skill content as weight increased. There was a decided increase in performance time as weight increased.

In stocking shelves, the skill content and performance time increased as distance increased but at a much lower rate.

In moving boxes from stack to conveyor, there was a very slight increase in skill as distance increased. Performance time increased as skill increased but at a much lower rate.

CHAPTER IX

CLASSIFICATION OF PRODUCTS

The T&S Tables include data from the handling of a good many different commodities. These commodities were selected to cover a wide range of sizes, shapes and weights. Each commodity, with perhaps the exception of eggs, was selected with the idea that it would represent a great number of other commodities of similar size, shape and weight. Eggs are of enough importance to warrant including whether egg handling data can be projected to cover other commodities or not.

Some testing was done to see how well the data from one commodity might be projected to cover other commodities of a similar size, weight and shape. The degree of similarity which was considered acceptable permitted a fair amount of difference in product characteristic. The key point is not how similar they appear to be, but how closely they compare in handling characteristics. The table data for "roughly round or oblong fruits or vegetables, 1/4 to 3/4 pounds in weight" was based upon the handling of apples. Oranges, lemons and potatoes were believed to be quite similar in handling characteristics. In performing this test, the same motion pattern was used for all four commodities. Cycle time values are listed here to show how closely they compare:

		Cycle Time
MP8	Potatoes	60
MP9	Lemons	60
MP10	Apples	61
MP11	Oranges	63

One would not be far astray in using the apple data for the other three commodities.

Projections of the table data to cover other commodities is naturally not as reliable as limiting the applications to the specific commodities upon which the table data is based. However, projecting data taken from the handling of apples to provide an estimate of time required to handle tomatoes can be done with a reasonable degree of accuracy. Until precise data is available from the handling of all commodities, projections such as this are the most feasible alternative.

The following list of commodities is given in alphabetical order with a sentence or two evaluating the relationship between the particular commodity and an appropriate part of the tables. In making these estimates, the project staff had the experience of collecting the table data and of collecting other data in preliminary investigation of a good many commodities other than those upon which the tables were directly based.

1. Apple sauce, buffet size can, stock shelves. The size of can determines the handling characteristics rather than the contents. Preliminary test data shows that buffet cans require 3 per cent less cycle time than 303 cans.

2. Apricots, in jumble packing. The handling characteristics would be the same as lemons. Lemons are included in the tables.

3. Avacadoes, wrap and layer pack. Time requirement would be a little greater than wrapping and layer packing apples. The difference in shape would increase the cycle time requirements 5 per cent by increasing the position-release time. For larger sizes add an additional 5 per cent to grasp and position-release.

4. Baby food, large and small jars, stock shelves. The time requirements for handling these would be the same as for handling pint jars.

5. Baby food meat, small cans, stock shelves. The time requirements for handling these would be the same as for handling 303 cans. The reduction in weight would be compensated for by a slightly more difficult positioning.

6. Baking powder in cans, stock shelves. The time requirements would be the same as 303 cans.

7. Baking soda, box, stock shelves. Data for handling 1/2 pound boxes would be the same as handling baking soda boxes.

8. Bananas, in hands, stock display bin. These would correspond in time requirements to handling bunch vegetables.

9. Beets in one or two pound bunches, stock display bin. Some preliminary test data indicates that handling bunches of beets requires 10 per cent more cycle time than handling bunch vegetables. The additional time required is in move and position-release.

10. Bread, stock shelves. The best estimate for handling bread could be obtained from the data for handling two-pound bags.

11. Broccoli in one- or two-pound bunches, stock display bin. Same as data for handling bunch vegetables.

12. Cantaloupes of one and two pounds, stock display bin. One-pound grapefruit or two-pound cabbage in the T&S Tables apply to the handling of cantaloupes of similar weight.

13. Carrots, one- or two-pound bunches with tops, stock display bin. Some preliminary test data indicates that handling bunches of carrots require 20 per cent more cycle time than handling a similar weight bunch of celery. Added time required is in move and position-release.

14. Cauliflower of one or two pounds, stock display bin. Time requirements would be 5 per cent greater than for handling a similar weight cabbage.

15. Cheese spread in 8-ounce glasses, stock shelves. Time requirements would be the same as for handling pint jars. Position-release time 10 per cent greater for awkward shapes.

16. Cheese one pound in wedge-shaped packages, stock refrigerator. The time requirements are the same as for handling one-pound bunch vegetables except that 10 per cent should be added to reaches and moves for the necessary change of direction which occurs during the reach and moves when loading a refrigerator display.

17. Chinese cabbage of one or two pounds, stock display bin. Some preliminary test data indicates that commodity corresponds to bunch vegetables in handling time.

18. Coffee in one-pound cans, stock shelves. Time requirements are the same as for 46-ounce cans. The effect of the lower weight is offset by the larger diameter, which makes the grasp more difficult while position-release is simplified.

19. Coffee in one-pound bags, stock shelf. Apply data for handling one-pound bags.

20. Coffee, soluble in small jars, stock shelves. Preliminary test data indicates that only 3 per cent less cycle time would be needed for these than is needed for handling pint jars. The move time is decreased, due to lower weight.

21. Collards in one- and two-pound bunches, stock display rack. Collards are somewhat bulkier than celery and would, for that reason, require 10 per cent more cycle time regardless of distance. Grasp and move are the motions affected.

22. Cornflakes, stock shelves. The handling time for cornflakes should be the same as handling time for 2 1/2 pound boxes. The 2 1/2 pound boxes upon which the T&S tables data are based were smaller but heavier than a box of cornflakes.

23. Corn, fresh green, stock display bin. Time requirements for handling corn in the husk would correspond with the handling time for one-pound bunch vegetables.

24. Crackers, 1/2 pound box, stock shelves. The time requirements should be the same as for handling one-pound boxes.

25. Crackers, one-pound box, stock shelves. Cycle time requirements for handling one-pound boxes of crackers would be 5 per cent greater than the table values for one-pound boxes, because the cracker box is large, and more difficult to grasp.

26. Cut flowers in bunches, pack in cardboard carton. The shape of this commodity is similar to bunch vegetables. However, the more difficult grasp, the fragility of the product and the more precise positioning make the cycle time requirements the same as packing eggs with a simo grasp of two eggs in each hand.

27. Dog food in cans, stock shelves. The can is about the same size as a 303 can and time requirements would be the same as the time requirements for handling 303 cans.

28. Eggs, small, pack in case or place on grader track. The cycle time requirements would be 5 per cent less than the table values for handling eggs because the table values were obtained from the handling of medium and large eggs. The grasp and position-release are affected.

29. Eggs, jumbo size, pack in case or place on grader track. The cycle time requirements for packing these would be 10 per cent more than is indicated in the table data, because many of these have to be pushed into the egg filler. They will not drop in as easily as the medium and large eggs. However, there would be no difference in time requirements for putting jumbo eggs on grader track and the time values given in the table for that operation.

30. Egg plant of one-pound weight, stock display bin. The time requirements are the same as for handling one-pound grapefruit.

31. Endive, one pound, stock display bin. Cycle time requirements 5 per cent greater than for handling one-pound grapefruit due to bulkiness of endive. The grasp is affected.

32. Frozen fish, one-pound box, load refrigerator display. The handling time would be the same as for handling the one-pound boxes listed in the tables, except that 10 per cent should be added to the reach and move value because of the change of direction which must be made in reach and move.

33. Grapes in one or two pound bunches, stock display bin. Cycle time requirements would be 15 per cent greater than for handling the same weight in bunch vegetables because the grapes are more fragile and are not tightly bunched. The grasp, move and position-release are affected.

34. Green onions, one-pound bunches, stock display bin. These would have the same time requirements as one-pound bunch vegetables.

35. Honey, one-pound jar, stock shelves. These have the same time requirements as the table values for handling pint jars.

36. Ice cream in one quart rectangular container, stock refrigerated display. These have the same time requirements as 2 1/2 pound boxes except that 10 per cent should be added to the reach and move time because of the necessary change of direction in the reach and move.

37. Ice cream in one quart cylindrical containers, stock refrigerated display. These should require the same handling time as the table values for quart jars except that 10 per cent should be added to the reach and move time because of the necessary change of direction in the reach and move.

38. Jello, in boxes, stock shelf. Time requirements for handling 2 Jello boxes per hand the same as for handling one 1/2 pound box per hand. Grasps are similar.

39. Juice, small cans, frozen concentrate, pile in refrigerated display case. The reach and grasp values would be the same as for handling 303 cans. The move and release would require less control than is indicated for 303 cans because the juice cans are not stacked. The move and release for jumble packing apples should give the best estimate. Finally, 15 per cent should be added to the reach and move time because of the necessary change of direction in reach and move and the coldness and moisture on the cans.

40. Ketchup in bottles, stock shelves. These have the same time requirements as the seven-ounce bottles listed in the tables.

41. Lettuce in one-pound heads, stock display bin. The cycle time requirements would be 5 per cent greater than for one-pound grapefruit because the lettuce heads are bulky and not firm. The grasp and move are affected.

42. Limes, jumble pack. These have the same time requirements as lemons which are listed in the tables. Allowance, of course, should be made for the number handled per cycle.

43. Meat, prepackaged in trays one- and two-pounds in weight, stock refrigerated display case. These should require the same time as handling a similar weight bunch vegetable except that 10 per cent is added to reaches and moves for the necessary change of direction in reach and move.

44. Muskmelon, two-pound weight, stock display bin. These have the same time requirements as two-pound cabbage.

45. Milk, quarts in paper cartons, stock refrigerator. Time requirements would be the same as for handling 2 1/2 pound boxes except add 5 per cent to cycle time for moisture on containers and 10 per cent for move and reach to allow for change in direction.

46. Milk, large evaporated in cans, stock shelves. Time requirements the same as for handling 303 cans.

47. Mustard in jars, stock shelves. The time requirements would be the same as for handling pint jars.

48. Mustard greens in one-pound bunches, stock display bin. The cycle time requirements would be 10 per cent greater than for handling one-pound bunch vegetables because the mustard is bulky and not firm. Grasp and move are the motions affected.

49. Nectarines, jumble pack. The time requirements would be the same as for lemons.

50. Onions, jumble in crates. The time requirements would be the same as for apples.

51. Olives in jars, stock shelves. Cycle time requirements for large jars the same as for pint jars. For smaller sizes in tall jars, add 10 per cent for position-release and deduct 5 per cent for grasp.

52. Peaches, wrap and layer pack. Time requirements for green-ripe peaches the same as for wrapping and layer packing apples.

53. Peaches, jumble pack. Time requirements for green-ripe peaches the same as for jumble packing apples.

54. Peanut butter in glass jars, stock shelves. Time requirements would be the same as for pint jars.

55. Pears, wrapping and layer packing. Cycle time requirements should be 5 per cent greater than for wrapping and layer packing apples because the shape of the pear is not as convenient for wrapping and positioning.

56. Pears, jumble pack. Time requirements would be the same as for jumble packing apples.

57. Pineapple, two-pound weight, stock display bin. Cycle time requirements would be 25 per cent greater than for two-pound cabbage. The grasp and position-release would be affected.

58. Peppers, jumble pack. Time requirements would be the same as for jumble packing apples.

59. Plums, jumble pack. Time requirements would be the same as for lemons. The advantage which plums have in smaller size is offset by greater fragility.

60. Pumpkin, three-pound weight, stock display bin. Time requirements would correspond to the time requirements for three-pound cabbage.

61. Radishes, bunched with tops, stock display bin. Time requirements for handling 2 bunches at a time the same as for one-pound bunch vegetables.

62. Rutabagas, two or three pounds, stock display bin. Cycle time requirements would be the same for either of these weights as it is for two-pound cabbage except if waxed, add 30 per cent to grasp.

63. Salad oil bottle, stock shelves. Time requirements would be the same as for seven-ounce bottle included in the tables.

64. Salt in one-pound cylindrical container, stock shelves. Time requirements would be the same for a pint jar.

65. Salt in one-pound box, stock shelves. Time requirements would correspond with time for one-pound boxes listed in the tables.

66. Shortening, three-pound can, stock shelves. Time requirements would be the same as for the 46-ounce cans listed in the tables.

67. Soup in cans, stock shelves. Time requirements would be the same as for 303 cans included in the tables.

68. Squash, one-pound butternut, stock display bin. Time requirements would be the same as time requirements for handling one-pound grapefruit.

69. Squash, one-pound yellow straight neck, stock display bin. Time requirements would be the same as for one-pound bunch vegetables.

70. Sugar, five-pound bags, stock shelves. Time requirements would be the same as for handling five-pound boxes.

71. Sugar, ten-pound bags, stock shelves. These will ordinarily require both hands to handle one bag but handling time would be 10 per cent less than for handling a five-pound box in each hand.

72. Sweet potatoes, jumble on display bin. These require 5 per cent more cycle time than for handling potatoes. Grasps and position-release are affected.

73. Tangerines, jumble on display bin. These require the same amount of time as lemons, which are included in the table data.

74. Tomatoes in No. 2 1/2 can, stock shelves. Preliminary test data indicates that the cycle time requirements for handling these would be about 5 per cent greater than for handling 303 cans. The grasp is affected.

75. Tomato paste in cans, stock shelves. Cycle time requirements for handling these would be 15 per cent greater than the time requirements for handling 303 cans. The position-release is affected.

76. Tomatoes, green-ripe, jumble on display bin. Cycle time requirements would be 5 per cent greater than for handling apples, due to the greater fragility of tomatoes. The grasp and position-release are affected.

77. Tuna fish in cans, stock shelves. Time requirements would be the same as for handling 303 cans. Grasp is easier but position-release is more difficult.

78. Turnips with tops in one- or two-pound bunches, stock display bin. Preliminary test data indicates that these would require 10 per cent more cycle time to handle than bunch vegetables of a comparable weight. Move and position-release are affected.

79. Vinegar in half gallon jugs, stock shelves. Preliminary test data indicates that these would require 10 per cent more time to handle than the quart bottles of milk.

80. Watermelon of 25-pound weight. These would take 20 per cent longer to handle than 25-pound bags because of greater fragility. The move and position-release are affected.

81. Weiners in one-pound packages, stock refrigerated display case. These would require the same time to handle as one-pound bags, but 10 per cent should be added to the reach and move time because of the necessary change of direction in reach and move.

82. Yams, jumble on display bin. These would require 5 per cent more cycle time as potatoes, which are included in the tables. The grasp and position-release are affected.

CHAPTER X

SIMPLIFIED TABLES

Tables of predetermined motion time standards have been received with considerable favor in industrial circles. One of the greatest disadvantages of these tables has been the difficulty encountered in training men to use them accurately. It is most difficult to describe a specific object in general terms so that another person will know without a doubt what is described. How much describing would have to be done to be certain that another person would know that one meant an egg if the word egg could not be used. The people who originate these generalized tables know what the motion descriptions refer to but there is considerable doubt that their knowledge is transferable in any practical period of training time.

At the beginning of this project the objective was to produce a generalized table such as several which are now in use in industry, but to include the motions which are peculiar to the handling of agricultural commodities. As work progressed, it became apparent that the generalized tables are greatly oversimplified. There are important factors for which they do not account. The generalized tables appear to be complete simply because they are presented in such a form that one cannot see just what is missing. If the factors which affect motion performance were more thoroughly understood, the missing data would be quite apparent.

After collecting some considerable volume of data, it was decided that this data would be presented in not just one table but in several. At least one table would be constructed to represent each of eight distinctly different commodity classes. As the work progressed, it became apparent that even these eight commodity classes would not be enough. There was a necessity to separate within a commodity class according to the nature of the work operation. By making such a breakdown, the user of such data can go with certainty to the proper commodity class and type of work operations for the data he needs.

Roughly Round or Oblong Fruits and Vegetables

Most of the data for this section was collected from the handling of apples. Several other commodities were handled to see how they compared. These included oranges, lemons, and potatoes in the same weight range with apples. Heavier weights were represented by one-pound grapefruit, two-pound cabbage, and three-pound cabbage.

Even though the commodities in the same weight range with apples did not appear to cause any significant discrepancy in the data, it is believed that for application, a separate table should eventually be prepared for each separate commodity. Even though two commodities

appear to be quite similar, the user of the data does not know when he might encounter a significant descrepancy. He cannot be certain that apple data can be applied to oranges in all possible motions. Those who construct the tables are in a better position to make such projections. This view is expressed in a desire to get away from the inaccuracies and misunderstanding caused by overgeneralization.

Even so, it is recognized that it will be a long time until data have been collected on all commodities. In the meantime, the data which have been collected provide better answers than sheer guesswork, even when this data must be projected to cover commodities which differ quite a lot from those upon which the collected data are based. A large proportion of commodities compare quite closely with the commodities upon which the collected data are based. Projecting the data to cover these is reasonably safe.

Tables of data are uniquely appropriate for agricultural commodities. Unlike the products of industry, agricultural commodities change but very little over long periods of time. Data which is collected now will not be obsolete many years hence. Handling an egg is probably no different today than it was in earliest history. There have been large volumes of data collected on the handling of agricultural commodities in recent years. The work has been done in many different places and by different people. The total amount of work done would probably be sufficient to provide time data for the common handling operations of every agricultural commodity. The lack has been in standardizing the data collection technology, and in compiling and cataloging the data. It is believed that the procedures developed and the data collected in this project will help in all three of these phases.

The following tables are designated "Simplified Tables" for two reasons. First, there is only one time value given for each particular motion. In the actual collection of data, when a particular motion is replicated, the time value will not be an exact duplicate. Usually it will be very close to the same, but there is almost always a slight difference. The average value of the replicates is given in these tables. Secondly, the motion values are adjusted so that the appropriate motion carries the effect of a particular factor. This point is illustrated in the case of a particular reach preceding a simple grasp in one instance, and the same reach preceding a complex grasp in the second instance. Film analysis invariably shows the latter reach to require more time. In setting up the simplified tables, the reach preceding a complex grasp is given the same time value as the same reach preceding a simple grasp. The extra time for this reach is added on to the complex grasp value. Thus the combined value of the reach and the complex grasp was not changed.

Jumble Packing Apples and Other Fruits and Vegetables of Similar Size and Shape, Weight 1/4 to 3/4 Pound

The work involved in jumble packing entails a minimum of manipulative motions and is, consequently, low in skill requirements. The

apples, or other commodities are grasped from a flat surface such as the bottom of a bin or a belt, where they are in a jumbled or random location. They are moved to the crate with no orienting of the fruit and are released with no precise positioning. The data in this section refers only to work done with both hands.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis for subclassification used is distance. Only side reaches were used in the packing houses observed. Front reaches could be used, but the distance reached is somewhat more limited in front reaches.

Inches	Winks
16	20
20	21
24	22
28	23
32	25

Grasp:-- The motion grasp refers to obtaining control of the object with the fingers. There were four subclasses of grasp used in jumble packing. The single grasp refers to a simple grasp of only one object in a hand. The simo grasp refers to the simultaneous grasping of two objects in the same hand. In actual practice it was not always completely simultaneous. Sometimes the second object would be a few inches from the first. In those cases, the first object would be slid toward the second and the grasp completed as nearly simultaneously as possible. The pincer grasp refers to a simo grasp of two apples in each hand followed by the grasping of another object between the middle fingers of the two hands. The total number of objects grasped in both hands is five. The two plus one grasp refers to a simo grasp of two objects in a hand followed by grasping a third in the same hand by placing the middle finger over it and holding it against the first two.

Type	Winks
single	4
simo	13
pincer	28
two plus one	34

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis used for subclassification is distance.

Inches	Winks
16	20
20	21
24	23
28	25
32	27

Release:-- The motion release corresponds to the therblig classification release load. The single release refers to a simple release of one object. The simo two release refers to the simultaneous releasing of two objects. The simo three release refers to the simultaneous releasing of three objects. The pincer release refers to the releasing of five objects with both hands following a pincer grasp.

Type	Winks
single	2
simo 2	3
simo 3	3
pincer	6

Note:-- Oranges, lemons and potatoes were substituted for apples in order to determine whether or not data taken from apples could be used for other commodities of a similar size, shape, and weight. When apple handling time requirements are taken as 100, oranges are 103, lemons 98, and potatoes 98.

Layer Packing Apples Weight 1/4 to 3/4 Pound,
One Hand Motion Patterns Only.

In layer packing, each fruit is oriented so that the cheek is up and the core parallel with the width of the crate. Each apple is positioned in the layer before releasing. There is substantially more manipulation of the fruit than in jumble packing and consequently more skill is required.

Actually both hands are used in these motion patterns, but the left hand is used only to hold the fruit in position in the layer. The active work is all done with the right hand.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis for subclassification used is distance.

Inches	Winks
12	16
18	17
24	18
30	21
36	24

Grasp:-- The motion grasp refers to obtaining control of the object with the fingers. The single grasp refers to a simple grasp of only one object in a hand. The simo grasp refers to the simultaneous grasping of two objects in the same hand. In actual practice, it was not always completely simultaneous. Sometimes the second object would be a few inches from the first. In those cases the first object would be slid

toward the second and the grasp completed as nearly simultaneously as possible.

Type	Winks
single	2
simo	10

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis used for subclassification is distance.

Inches	Winks
12	16
18	17
24	18
30	21
36	24

Position-release:-- In this instance the motion is not just a simple release. It is a combination of orient, position, and release. Orient refers to the turning of an apple so that the cheeks are up and the cores are parallel with the width of the box. Position refers to the precise placing of the fruit in its position in the crate. Release refers to the separation of the fingers from the object which has been grasped. It corresponds to the therblig classification release load.

Type	Winks
single	11
consecutive two	42

Layer Packing Apples - Weight 1/4 to 3/4 Pound, Two Hand Motion Patterns

In Layer packing, each fruit is oriented so that the cheek is up and the core parallel with the width of the crate. Each apple is positioned in the layer before releasing. There is substantially more manipulation of the fruit than in jumble packing, and consequently more skill is required.

A double tilt crate holder was used for this work so that the apples stayed in position in the layer by gravity. Both hands were released for active work.

Reach:-- The motion reach corresponds to the therblig classification of release load. The only basis for subclassification used is distance.

Inches	Winks
16	20
20	21
24	22
28	23
32	25

Grasp:-- The motion grasp refers to obtaining control of the object with the fingers. The single grasp refers to a simple grasp of only one object with a hand. The simo grasp refers to the simultaneous grasping of two objects in the same hand. In actual practice, it was not always completely simultaneous. Sometimes the second object would be a few inches from the first. In those cases the first object would be slid toward the second and the grasp completed as nearly simultaneously as possible. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the first fruit and then a second grasp of another fruit in the same hand.

Sometimes grasps are made from a flat surface such as a moving belt or the bottom of a bin or box. In other instances the grasps are made from fruit jumbled in depth such as in a filled bin or box. The latter condition increases the difficulty of grasps.

Type of Grasp	Winks
single (flat surface)	4
simo (flat surface)	13
simo (jumbled in depth)	17
consecutive (flat surface)	31
consecutive (jumbled in depth)	36

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis used for subclassification is distance.

Inches	Winks
16	20
20	21
24	23
28	25
32	27

Position-release:-- In this instance the motion is not just a simple release. It is a combination of orient, position, and release. Orient refers to the turning of an apple so that the cheeks are up and the cores parallel with the width of the box. Position refers to the precise placing of the fruit in its position in the crate. Release refers to the separation of the fingers from the object which has been

grasped. It corresponds to the therblig classification of release load. Position-releases are easier when they follow very precisely executed grasps. The single and consecutive grasps from a flat surface can be quite precisely executed. The fruit can be almost completely oriented as it is grasped. The simo grasp permits almost no orienting during the grasp, so orienting must be executed during subsequent motions. The grasping of fruit from a filled bin or crate, i.e. jumbled in depth, adds even more irregularity to the grasp. Because of the influence of type-of-grasp on position-release, the position-release types must be classified on this basis also.

Types of Position-release	Winks
Single following single grasp from flat surface	12
Consecutive following consecutive grasp from flat surface	54
Consecutive following consecutive grasp from fruit jumbled in depth	59
Consecutive following simo grasp from flat surface	56
Consecutive following simo grasp from fruit jumbled in depth	69

Note:-- Packing in the bottom of the crate takes 10 percent more time than packing in the top of the crate.

Wrap and Layer Pack Apples - Weight 1/4 to 3/4 Pound, Two Hand Motion Pattern

This type of pack is commonly used by shippers who are long distances from their retail market. Each individual apple is wrapped in a tissue and placed in the crate in layers according to a specific symmetrical pattern. This pattern varies depending on the size of the fruit. The tissue dispenser is placed on the side of the crate next to the left hand. The apple bin or belt is on the right side. The work done by the left hand constitutes a heavier work load than the work done by the right hand throughout the cycle. Time requirements for the cycle are therefore determined by the motions performed by the left hand. For that reason, the data refers to the motions of the left hand.

Reach to Paper Dispenser:-- The motion reach corresponds to the therblig classification of transport empty.

Inches	Winks
12	14

Grasp One Tissue Wrap:-- The motion grasp refers to obtaining control of the object with the fingers. The palm and fingers are placed almost in the center of the paper and almost flat down on it. A short contraction of the first and middle finger toward the thumb tears the tissue loose.

Grasp Tissue	Winks
single grasp	2

Move:-- The motion move corresponds to the therblig classification of transport loaded. The tissue is moved to a position over the fruit in the crate.

Inches	Winks
12	20

Transfer Grasp:-- The left hand, while holding the tissue palm up, receives the apple from the right hand. During the preceding phase, the right hand has obtained one apple from the bin or belt and moved it to the left hand. The apple is dropped on the center of the tissue.

Grasp	Winks
transfer	4

Wrap and Move:-- Both hands are used to curl the tissue over the apple. While the wrapping is being completed, the apple is being moved toward its final destination in the crate. After the wrap motions terminate, the left hand alone continues to move the wrapped apple to its position in the crate.

Wrap and Move Inches	Winks
12	42

Position-release:-- In this instance the motion is not just a simple release. It is a combination of orient, position, and release. Orient in this case, refers to the turning of an apple so that the core is vertical. Position refers to the precise placing of the wrapped fruit in its position in the layer pattern. Release refers to the separation of the fingers from the object which has been grasped. It corresponds to the therblig classification of release load.

Type Position-release	Winks
single	11

Note:-- While the left hand is placing the wrapped apple in the proper position in the crate, the right hand is usually engaged in a balancing delay or in some extra motion calculated to prevent the right hand from obtaining another apple and arriving in position over the crate before the left hand can finish placing the apple and obtain another tissue.

Stock Fruit and Vegetable Bin from Packing Crate
Weights One, Two and Three Pounds

The work involved in stocking a fruit or vegetable bin is similar to jumble packing apples in level of skill required. There is a minimum of manipulative motions and consequently low skill requirements. Grasps are made from a filled packing crate. The item is moved

to the display bin with no orienting and is released with no precise positioning. The data in this section refers only to work done with both hands.

Reach:-- The motion reach corresponds to the therblig classification of transport empty. The only basis for subclassification used is distance.

Inches	Winks
18	17
24	20
30	21
36	23

Grasp:-- The motion grasp refers to obtaining control of the object with the fingers. The single grasp refers to a simple grasp of only one object with a hand. The grasp one with both hands refers to the grasping of objects too large to be conveniently controlled by one hand alone. Both hands grasp the same object between the hands.

All grasps were made from a packing crate. Grasps were also subclassified according to the weight of object handled.

Type of Grasp	Winks
single-1 pound grapefruit	9
single-2 pound cabbage	11
grasp one with both hands-three pound cabbage	10

Move:-- The motion move corresponds to the therblig classification of transport loaded. The only basis for subclassification used is distance.

Inches	Winks
18	24
24	25
30	28
36	30

Release:-- The motion release refers to the separation of the fingers from the object which has been grasped. The single release refers to a release of one object from a hand. The release one with both hands refers to releasing a single object which has been grasped between the two hands. This occurs in handling larger objects. No orienting and no apparent positioning occurred in these releases. Releases were classified on a weight basis also.

Type of Release	Winks
single-one pound grapefruit	8
single-two pound cabbage	11
release one with both hands-three pound cabbage	11

Bunch Vegetables

The data for this section was obtained from the handling of celery. Celery was the only representative from the class of bunched vegetables.

Stocking Display Racks with Celery Weights One and Two Pounds

The work involved in stocking a display rack with celery involves a minimum of manipulative motions and is, consequently, low in skill requirements. The celery is grasped from the packing crate. It is moved to the display rack with no orienting. It is released with no precise positioning. The data in this section refers only to work done with both hands.

Reach:-- The motion reach corresponds to the therblig classification of transport empty. The only basis for subclassification used is distance.

Inches	Winks
18	18
24	20
30	22
36	24

Grasp:-- The motion grasp refers to obtaining control of the object with the fingers. Only the single grasp was used, but this was subclassified on the basis of weight. All grasps were made of celery from a celery packing crate.

Type of Grasp	Winks
single-one pound	10
single-two pound	11

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis for subclassification used is distance.

Inches	Winks
18	31
24	34
30	36
36	38

Release:-- The motion release refers to the separation of the fingers from the object which has been grasped. All of the releases used in handling bunch vegetables were single releases; that is, the release

of one object from a hand. These releases were subclassified on the basis of weight.

Type	Winks
single-one pound	3
single-two pound	6

Eggs

All of the data for this section was obtained from the handling of real eggs.

Moving Eggs from an Egg Basket to the Track of an Egg Grader

Loading an egg grader entails about the same level of manipulative motions as layer packing apples. The eggs are grasped from a filled egg basket. They were oriented so that the long axis of the egg lay across the two sides of the feed track during the move. They were positioned on the feed track before releasing. The fragility of the egg increased the performance time quite noticeably. Workers who attempted to work too fast would begin to break a large number of eggs. All data was taken from two handed work.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis for subclassification used is distance.

Inches	Winks
12	19
18	24
24	28

Grasp:-- The motion grasp refers to obtaining control of the egg with the finger. The single grasp refers to a simple grasp of one egg per hand. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the first egg, then a single grasp of a second egg in the same hand. The simo grasp refers to the simultaneous grasping of two eggs in the same hand. In actual practice it is not always completely simultaneous but is as nearly simultaneous as can be done. All grasps are from a filled egg basket.

Type of Grasp	Winks
single	9
consecutive	38
simo	24

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis for subclassification used is distance.

Inches	Winks
12	22
18	24
24	26

Position-release:-- In this instance the motion is not just a simple release. It is a combination of orient, position, and release. Orient refers to the turning of the egg so that its long axis lays across the sides of the grader loading track. Position refers to the precise placing of the egg on the grader loading track. Release refers to the separation of the fingers from the egg. It corresponds to the therblig classification release load. The difficulty of performing position-release was noticeably affected by the type of grasp which it followed. Type of grasp has therefore been included here as a basis for subclassifying position-release.

The single position-release refers to the orienting, positioning and release of one egg per hand. The consecutive position-release refers to a single position-release followed by a regrasping of a second egg from the same hand.

Type of Position-release	Winks
single	4
consecutive following consecutive grasp	35
consecutive following simo grasp	42

Note:-- The cycle required about eight percent more time to perform when reaches and moves were done to the side rather than to the front. This effect is probably due to the greater control required in terminating the move when the track is approached from the side. When the track is approached from the front, the move is in line with the track and the egg may be placed anywhere along several inches of the track. However, when the track is approached from the side, the move is at a right angle to the track and consequently, the move must terminate at a more precise point. The egg must be placed on the track and the track is only about one and one-half inches wide.

Moving Eggs from Bin to Egg Case

Packing eggs in a case entails about the same level of manipulation as loading an egg grader or layer packing apples. This means that the skill content is also about equal. The eggs are grasped from the flat surface of the grader bin. During the move and at the end of the move the eggs are oriented so that the pointed end is down. At the end of the move the egg is positioned over the cell in the filler and

released. The fragility of the egg increased the performance time substantially. Workers who attempted to work too fast would begin to break a large number of eggs. All data was taken from two handed work.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis for subclassification used is distance.

Inches	Winks
12	19
18	24
24	28

Grasp:-- The motion grasp refers to obtaining control of the egg with the fingers. The single grasp refers to a simple grasp of one egg per hand. The consecutive grasp refers to a single grasp followed by a regrasp or palming of the first egg, then a single grasp of a second egg in the same hand. The simo two grasp refers to the simultaneous grasping of two eggs in the same hand. In actual practice it is not always completely simultaneous but is as nearly simultaneous as can be done. The two-plus-one grasp refers to a simo grasp followed by a regrasp or palming of these eggs, then a single grasp of a third egg in the same hand. The simo three grasp refers to the simultaneous grasping of three eggs per hand. In actual practice it is not always completely simultaneous but is as nearly simultaneous as can be done. All grasps are from the bin of an egg grader.

Type of Grasp	Winks
single	9
simo two	20
consecutive two	36
simo three	43
two plus one	63

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis for subclassification used is distance.

Inches	Winks
12	22
18	24
24	26

Position-release:-- In this instance the motion is not just a simple release. It is a combination of orient, position, and release. Orient refers to the turning of the egg so that its long axis is vertical and its pointed end down. Position refers to the precise placing of the egg over the cell in the cardboard filler. Release refers to the separation of the fingers from the egg. It corresponds to the therblig

classification release load. The difficulty of performing position-release was noticeably affected by the type of grasp which it followed. Type of grasp has therefore been included here as a basis for sub-classifying position-release.

The single position-release refers to the orienting, positioning and release of one egg per hand. The consecutive two position-release refers to a single position-release followed by a regrasping of a second egg from the palm to the fingers, then a position-release of a second egg from the same hand. The consecutive three position-release refers to three single releases performed consecutively with eggs all from the same hand. It always follows a simo three or two plus one grasp.

Type of Position-release	Winks
single	4
consecutive two after consecutive grasp	27
consecutive two after simo grasp	40
consecutive three after two plus one grasp	60
consecutive three after simo three grasp	76

Note:-- The cycle required 12 percent more time when packing in the bottom of the case than when packing in the top of the case.

Weighing Eggs on the Small One Egg Capacity Egg Scale

This operation is frequently found where only a small volume of eggs are to be weighed. These scales have only one cup; consequently, the work is mostly one handed. Usually eggs are cleaned along with this operation and the left hand is employed to hold either the egg or cleaning cloth. Only one distance was obtained for this operation. The skill level is a little lower than for the other two egg operations because it is primarily a one handed operation.

Reach:-- The motion reach corresponds to the therblig classification transport empty. Reaches were made to an egg basket and to the cup of an egg scale. There appeared to be no difference between them.

Inches	Winks
12	17

Grasp:-- The motion grasp refers to obtaining control of the egg with the fingers. Only the single grasp was used in this instance; that is, a simple grasp of only one egg in a hand. The difficulty of the grasp was affected some by the source of the eggs. Grasps from the cup of the egg scales were a little harder perhaps because the positioning of the fingers had to be rather precise to avoid catching the cup along with the egg. Source was therefore used as a basis for subclassifying grasp.

Type of Grasp	Winks
single from egg basket	5
single from cup of egg scales	6

Move:-- The motion move corresponds to the therblig classification transport loaded. Moves were made to the cup of a single egg scale and to the left hand for a transfer release. There appeared to be no difference between them.

Inches	Winks
12	17

Position-releases:-- When eggs were placed in the cup of the egg scale, they had to be oriented so that the long axis of the egg was in the same direction as the long axis of the egg scale cup and the eggs had to be positioned precisely over the cup before releasing. When eggs were transfer released in the other hand, there was no necessity for either orienting or precise positioning. Only a simple release was needed.

Type of Release	Winks
single position-release on egg scale cup	6
single transfer-release in other hand	2

Cans

Most of the data for this section was obtained from the handling of No. 303 cans. Some preliminary tests indicated that there would be very little difference in performance time for the buffet, No. 2, and No. $2\frac{1}{2}$ sizes. The No. 303 was selected to represent these smaller sizes. Some motion patterns were done with 46-ounce juice cans. These showed a substantial difference from smaller cans. All data herein was taken from two handed operation.

Stocking Shelves with Cans - Labels Not Oriented

Cans are sometimes placed on shelves with no regard for direction of labels during rush hours and in making mass displays. This saves time.

The cans were grasped from the top layer of the case and moved to position on top of other cans already on shelf, positioned over these cans, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis for subclassification used is distance.

Inches	Winks
12	16
18	17
24	23
30	24
36	25

Grasp:-- The motion grasp refers to obtaining control of the can with the fingers. All grasps were made from a cardboard case.

The single grasp refers to a simple grasp of one can in a hand. The simo grasp refers to the simultaneous grasping of two cans in a hand. Both 303 cans and the 46-ounce cans were used. Can size provided a further basis for subclassifying grasps.

Type of Grasp	Winks
single 303 can	15
single 46-ounce can	20
simo 303 can	30

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis for subclassification used is distance.

Inches	Winks
12	23
18	25
24	26
30	30
36	33

Position-release:-- In this instance the cans had to be positioned rather precisely over other cans which were already on the shelf before releasing. The single position-release refers to the positioning and release of one can per hand. The simo position-release refers to the simultaneous positioning and release of two cans per hand. Both 303 cans and 46-ounce cans were used. Can size provided a further basis for subclassifying position-release.

Type of Position-release	Winks
single 303 can	13
single 46-ounce can	18
simo 303 can	34

Stocking Shelves with Cans - Labels Oriented to Face Customers

This is the customary way of stocking shelves with canned goods. The cans are grasped from the top layer of the case, moved to shelf, oriented so that labels face toward customers, positioned on top of another layer of cans on the shelf and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
12	16
18	17
24	23
30	24
36	25

Grasp:-- The motion grasp refers to obtaining control of the can with the fingers. All grasps were made from a cardboard case.

The transfer grasp refers to a single grasp of a can from one hand to the other. The single grasp refers to a simple grasp of one can in a hand. The grasp three with both hands refers to a single grasp of one can in each hand plus a third can sandwiched between the hands. The simo grasp refers to the simultaneous grasping of two cans per hand.

Type of Grasp	Winks
transfer grasp 303 can	9
single grasp 303 can	15
single grasp 46-ounce can	20
grasp three cans with both hands 303 can	26
simo grasp 303 can	30

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis for subclassification used is distance.

Inches	Winks
12	23
18	25
24	26
30	30
36	33

Position-release:-- In this instance the motion is not just a simple release. It is a combination of orient, position, and release. Orient refers to the turning of the cans so that can labels will face

outward from the shelf. Position refers to the precise placing of the cans over cans which were already on the shelf. Release refers to the separation of the fingers from the can.

The transfer-release refers to a simple release of a single can from one hand to the other hand. No orienting or positioning is required. The single position-release refers to the orienting, positioning and release of one can with a hand. The position-release three with both hands refers to a single position-release of the third can usually done with the right hand. The consecutive two position-release refers to a single position-release of one can followed by another single position-release of a second can from the same hand.

Type of Position-release	Winks
transfer-release 303 can	9
single position-release 303 can with 2 faced label	21
single position-release 303 can with ordinary label	36
single position-release 46-ounce can with ordinary label	45
position-release three with both hands 303 cans with ordinary labels	76
consecutive two position-release 303 cans with ordinary labels.	110

Glass Jars

The data in this section was obtained from the handling of pint and quart glass jars. All data herein was taken from two handed operations.

Stocking Shelves with Jars - Labels not Oriented

Jars were grasped from a cardboard case with a cardboard separator which formed an individual cell for each jar, moved to shelf, positioned on shelf, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
18	17
24	21
30	22
36	24

Grasp:-- The motion grasp refers to obtaining control of the jar with the fingers. All grasps were made from a cardboard case with cardboard separator which formed an individual cell for each jar.

Only single grasps were used in handling jars; that is, a simple grasp of one jar per hand. Both pint and quart jars were used, but size had no apparent effect on grasps.

Type of Grasp	Winks
single pint or quart jar	15

Move:-- The motion move corresponds to the therblig classification transport loaded. Both distance and size were used as basis for subclassification of move.

Pints

Inches	Winks
18	30
24	32
30	36
36	40

Quarts

Inches	Winks
18	36
24	39
30	43
36	48

Position-release:-- In this instance the motion was not just a simple release. The jars were positioned with some precision in order to form a symmetrical arrangement on the shelf before releasing. Only the single position-release was used and it did not seem to matter whether the pint or quart jars were being handled. There was no apparent difference due to size.

Type of Position-release	Winks
single pint or quart jars	10

Stocking Shelves with Jars - Labels Oriented to Face Customers

The jars were grasped from a cardboard case having a cardboard separator which formed an individual cell for each jar, moved to shelf, oriented so that labels faced outward from the shelf, positioned precisely in the proper place in symmetrical arrangement, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
18	17
24	21
30	22
36	24

Grasp:-- The motion grasp refers to obtaining control of the jar with the fingers. All grasps were made from a cardboard case having a cardboard separator which formed an individual cell for each jar.

Only single grasps were used in handling jars; that is, a simple grasp of one jar per hand. Both pint and quart jars were used, but size had no apparent effect on grasps.

Type of Grasp	Winks
single pint or quart jar	15

Move:-- The motion move corresponds to the therblig classification transport loaded. Both distance and size were used as basis for subclassification of move.

Pints

Inches	Winks
18	30
24	32
30	36
36	40

Quarts

Inches	Winks
18	36
24	39
30	43
36	48

Position-release:-- In this instance the motion is not just a simple release. The jars were oriented, positioned and released. Orient refers to turning the jars so that the jar labels face outward from the shelf. Position refers to the precise placing of the jar in its proper location in a symmetrical arrangement. Release refers to the separation of the fingers from the jar. Only the single position-release was used and it did not seem to matter whether pint of quart jars were being handled.

Type of Position-release	Winks
single pint or quart jars	35

Glass Bottles

The data in this section was obtained from the handling of seven-ounce soft drink bottles and quart milk bottles.

Stocking Shelf with Bottles - Labels Not Oriented

The bottles were grasped from the case, moved to shelf, positioned and released on the shelf in orderly pattern.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
18	17
24	20
30	22
36	24

Grasp:-- The motion grasp refers to obtaining control of the bottle with the fingers. Only single grasps were used in handling bottles; that is, a simple grasp of one bottle per hand. Both seven-ounce soft drink bottles and quart milk bottles were handled, but size had no apparent effect on grasps.

Type of Grasp	Winks
single seven-ounce or quart milk	12

Move:-- The motion move corresponds to the therblig classification transport loaded. Both distance and size were used as a basis for sub-classifying moves.

Seven-ounce Bottle

Inches	Winks
18	35
24	36
30	40
36	43

Quart Milk Bottle

Inches	Winks
18	37
24	40
30	45
36	50

Position-release:-- In this instance the motion was not just a simple release. The bottles were positioned with some precision in order to

form a symmetrical arrangement on the shelf before releasing. Only the single position-release was used. Size of bottle was used as a basis for subclassification.

Type of Position-release	Winks
single seven-ounce bottle	11
single quart milk bottle	14

Stocking Shelves with Bottles - Labels Oriented to Face Customers

Only the seven-ounce soft drink bottles were used in this operation. Milk bottles are seldom oriented for labels. The bottles were grasped from case, moved to shelf, positioned so that labels faced outward from the shelf, positioned so as to form a symmetrical arrangement of bottles, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
18	17
24	20
30	22
36	24

Grasp:-- The motion grasp refers to obtaining control of the bottle with the fingers. Only single grasps were used; that is, a simple grasp of one bottle per hand.

Type of Grasp	Winks
single seven-ounce bottle	12

Move:-- The motion move corresponds to the therblig classification transport loaded. The only basis used for subclassifying move was distance.

Inches	Winks
18	35
24	36
30	40
36	43

Position-release:-- In this instance the motion is not just a simple release. The bottles were oriented, positioned and released. Orient refers to turning the bottles so that the bottle labels face outward from the shelf. Position refers to the precise placing of the bottle

in its proper location in a symmetrical arrangement. Release refers to the separation of the fingers from the bottle. Only the single position-release was used; that is, only one bottle per hand was position-released.

Type of Position-release	Winks
single seven-ounce bottle	23

Bags

The data in this table was obtained from the handling of one and two pound paper bags, and 25 pound burlap bags. All of the data was taken from two handed operation.

Stocking Shelves with Bags - Labels Not Oriented

The bags were grasped from a case, moved to shelf, positioned on shelf, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
18	16
24	18
30	20
36	22

Grasp:-- The motion grasp refers to obtaining control of the bag with the fingers. Only single grasps were used; that is, a simple grasp of one bag per hand. Both one and two pound bags were handled, but weight appeared to have no effect on grasp.

Type of Grasp	Winks
single either 1 or 2 lb. bag	20

Move:-- The motion move corresponds to the therblig classification transport loaded. Both distance and weight were used as basis for subclassifying moves.

One Pound Bags	
Inches	Winks
18	27
24	29
30	33
36	36

Two Pound Bags

Inches	Winks
18	27
24	32
30	37
36	42

Position-release:-- In this instance, the motion was not just a simple release. The bags were positioned with some precision in order to form a symmetrical arrangement on the shelf before releasing. Only the single position-release was used. Size of bag did not appear to affect position-releases.

Type of Position-release	Winks
single either one or two lb. bags	10

Stocking Shelves with Bags - Labels Oriented to Face Customers

The bags were grasped from a case, moved to shelf, oriented so that labels faced outward, positioned on the shelf so as to form a symmetrical arrangement, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. The only basis used for subclassification is distance.

Inches	Winks
18	16
24	18
30	20
36	22

Grasp:-- The motion grasp refers to obtaining control of the bag with the fingers. Only single grasps were used; that is, a simple grasp of one bag per hand.

Type of Grasp	Winks
single one pound	20

Move:-- The motion move corresponds to the therblig classification transport loaded. Distance was the only basis used for subclassifying moves.

Inches	Winks
18	27
24	29
30	33
36	36

Position-release:-- In this instance, the motion was not just a simple release. The bags were oriented, positioned, and released. Orient refers to the turning of bags so that labels faced outward from the shelf. Position refers to the precise placing of the bags in order to form a symmetrical arrangement on the shelf before releasing. Release refers to the separation of the fingers from the bag. Only the single position-release was used.

Type of Position-release	Winks
single one pound	25

Moving 25 Pound Bags from Stack to Conveyor

The bags were grasped from a stack, moved to a conveyor, and released. No apparent positioning was required.

Reach:-- The motion reach corresponds to the therblig classification transport empty.

Inches	Winks
24	19

Grasp:-- The motion grasp refers to obtaining control of the bag with the hands. In this case, the bags were so large that both hands were required to grasp a single bag.

Type of Grasp	Winks
Grasp one with both hands 25 pound bag	14

Move:-- The motion move corresponds to the therblig classification transport loaded.

Inches	Winks
24	28

Release:-- In this instance the bag was simply released by both hands. No orienting and no apparent positioning were required.

Type of Release	Winks
Release one with both hands 25 pound bag	8

Boxes

The data in this table was obtained from the handling of boxes of the following weights: ½ pound, 1 pound, 2½ pound, 5 pound, 10 pound, 25 pound, and 50 pound.

Stocking Shelves with Boxes - Labels not Oriented

The boxes were grasped from a case, moved to shelf, positioned on shelf, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. Distance was the only basis used for subclassifying reaches.

Inches	Winks
18	16
24	19
30	21
36	24

Grasp:-- The motion grasp refers to obtaining control of the box with the fingers. Only single grasps were used; that is, simple grasps of one box per hand. Weight was used as a basis for subclassifying grasps.

Type of Grasp	Winks
single ½ pound	17
single 1 pound	17
single 2½ pound	17
single 5 pound	20

Move:-- The motion move corresponds to the therblig classification transport loaded. Both weight of object moved and distance are used to subclassify moves.

½ Pound

Inches	Winks
18	24
24	26
30	30
36	34

1 Pound

Inches	Winks
18	26
24	29
30	34
36	39

$2\frac{1}{2}$ Pound

Inches	Winks
18	28
24	32
30	36
36	40

5 Pound

Inches	Winks
18	33
24	39
30	44
36	50

Position-release:-- In this instance the motion was not just a simple release. The boxes were precisely placed so as to form a symmetrical arrangement before being released. Only single position-releases were used, but these were subclassified on the basis of weight.

Type of Position-release	Winks
single $\frac{1}{2}$ pound	14
single 1 pound	14
single $2\frac{1}{2}$ pound	14
single 5 pound	16

Stocking Shelves with Boxes - Labels Oriented to Face Customers

Boxes are grasped from a case, moved to shelf, oriented so labels face outward, positioned on shelf so as to form a symmetrical arrangement, and released.

Reach:-- The motion reach corresponds to the therblig classification transport empty. Distance was the only basis used for subclassifying reaches.

Inches	Winks
18	16
24	19
30	21
36	24

Grasp:-- The motion grasp refers to obtaining control of the box with the fingers. Only single grasps were used; that is, simple grasps

of one box per hand. Weight was used as a basis for subclassifying grasps.

Type of Grasp	Winks
single $\frac{1}{2}$ pound	17
single 1 pound	17
single $2\frac{1}{2}$ pound	17
single 5 pound	20

Move:-- The motion move corresponds to the therblig classification transport loaded. Both distance and weight were used as basis for subclassifying moves.

$\frac{1}{2}$ Pound

Inches	Winks
18	24
24	26
30	30
36	34

1 Pound

Inches	Winks
18	26
24	29
30	34
36	39

$2\frac{1}{2}$ Pound

Inches	Winks
18	28
24	32
30	36
36	40

5 Pound

Inches	Winks
18	33
24	39
30	44
36	50

Position-release:-- In this instance the box was not simply released. It was oriented, positioned, and released. Orient refers to the turning of labels so that they face outward from the shelf. Position refers to the placing of the boxes so as to form symmetrical arrangement. Release refers to the separation of the finger from the box.

Only single position-releases were used. Weight was used as a basis for subclassifying position-release.

Type of Position-release	Winks
single $\frac{1}{2}$ pound	23
single 1 pound	25
single $2\frac{1}{2}$ pound	25
single 5 pound	37

Move 10 Pound Boxes from Stack to Conveyor

Boxes are grasped from a stack, moved horizontally from left to right, and released on a conveyor with no apparent positioning.

Reach:-- The motion reach corresponds to the therblig classification transport empty. Distance was the only basis used for subclassifying reaches.

Inches	Winks
18	20
24	21

Grasp:-- The motion grasp refers to obtaining control of the box with the hands. A single 10 pound box is grasped with both hands.

Type of Grasp	Winks
grasp one with both hands	9

Move:-- The motion move corresponds to the therblig classification transport loaded. Distance was the only basis used for subclassifying moves.

Inches	Winks
18	24
24	26

Release:-- In this instance only simple releases were used. There was no orienting and no apparent positioning. One box was released with both hands.

Type of Release	Winks
release one with both hands	6

Move 25 and 50 Pound Boxes from Stack to Conveyor

Boxes were grasped from a stack, moved horizontally from left to right, and released on a conveyor. No apparent positioning was done.

Reach:-- The motion reach corresponds to the therblig classification transport empty. Distance was the only basis used for subclassifying reaches.

Inches	Winks
24	21
30	23
36	25
42	28
48	31

Grasp:-- The motion grasp refers to obtaining control of the box with the hands. A single box was grasped with both hands. Weight was used as a basis for subclassifying grasps.

Type of Grasp	Winks
grasp one with both hands 25 pound box	15
grasp one with both hands 50 pound box	18

Move:-- The motion move corresponds to the therblig classification transport loaded. Both distance and weight were used as bases for subclassifying moves.

25 Pound

Inches	Winks
24	34
30	36
36	37
42	39
48	41

50 Pound

Inches	Winks
24	39

Release:-- In this instance only simple releases were used. There was no orienting and no apparent positioning. One box was released

with both hands. Weight was used as a basis for subclassifying releases.

Type of Release	Winks
release one with both hands 25 pound box	8
release one with both hands 50 pound box	11

CHAPTER XI

VARIABILITY OF WORKERS INCLUDED IN THE SAMPLE

The table data refers to the average of fifteen persons performing at normal effort level. However, normal effort level varies quite widely from person to person. This section is presented in order to show just how widely individuals included in the sample departed from the average for all fifteen operators.

All motion patterns are put on a comparable basis by using the rate relative instead of raw data. The average time for an individual is divided into the average for all fifteen persons. This expresses the average normal time of all operators combined as a percentage of the individual's time. This measure was chosen because it corresponds conceptually to the "rating" of orthodox time study. This rating multiplied times the individual worker's actual performance time will give the average of all fifteen workers.

A rating of 100 is equal to the average normal performance time. It should be noted that the individual's time is not expressed as a percentage of the average of all workers. Consequently, the individual rate relatives do not average 100, but rather something over 100. However, the individual ratings for the different motion patterns do average in a range from 100.5 to 104.3, which permits their being combined to show the degree of dispersion.

Even though the rate relatives in this section were all limited to normal performance, the fastest operator was often twice as fast as the slowest for a particular motion. If the fast performance averages were also included, the fastest would be approximately four times as fast as the slowest. One can easily see the need for eliminating worker differences when appraising alternative methods.

The ratio of the slowest operator to the fastest operator was computed for each motion pattern. These calculations were made from the raw data. Exactly comparable ratios cannot be computed from the rate relatives because of decimal rounding as well as the nature of the relatives described above.

Table 3: Round or oblong fruits and vegetables: rate relatives for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number										
MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9	MP10	MP11
159	130	150	132	138	128	134	131	127	132	131
126	122	136	126	132	123	125	131	127	131	130
118	113	123	122	124	122	119	125	121	121	121
116	112	114	115	123	115	119	116	107	108	109
110	111	112	109	106	114	115	103	105	104	109
107	106	108	106	103	101	113	102	103	103	109
104	106	105	103	102	100	102	101	101	101	103
103	104	98	99	99	99	98	99	99	101	101
102	96	95	94	98	97	96	98	98	99	99
100	95	94	92	98	96	96	97	97	97	98
88	94	94	90	94	93	94	93	95	92	92
88	88	90	89	88	91	91	92	94	90	91
80	87	89	88	88	90	88	92	90	87	88
78	84	78	87	84	82	82	80	82	84	82
78	79	70	79	70	79	71	76	80	82	74

Motion Pattern Number										
MP12	MP13	MP14	MP15	MP16	MP17	MP18	MP19	MP20	MP21	MP22
137	130	121	138	127	134	122	123	120	121	121
132	118	118	128	127	121	120	114	118	118	117
131	117	117	124	115	114	115	111	115	112	116
115	117	110	117	114	112	114	106	110	108	112
105	114	109	114	112	109	113	104	109	107	110
102	113	108	111	111	105	104	103	101	106	107
101	103	107	106	104	103	100	102	100	98	103
96	103	106	104	99	103	100	100	100	97	101
95	98	105	98	96	101	96	100	99	95	101
94	98	90	95	96	98	96	99	98	94	99
94	97	88	92	89	91	93	98	95	89	90
93	84	88	90	89	86	90	95	93	89	89
86	83	87	82	86	86	90	90	88	83	88
84	80	86	81	83	83	85	87	86	--	85
78	78	84	69	81	82	82	83	84	--	82

Table 3: (Cont.) Round or oblong fruits and vegetables: rate relatives for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number									
MP23	MP24	MP25	MP26	MP27	MP28	MP29	MP30	MP31	MP32
120	119	161	140	146	139	127	137	140	139
115	116	137	120	125	118	114	128	130	121
114	110	128	117	121	117	113	118	124	121
109	109	119	116	118	116	113	115	114	111
108	104	118	111	116	109	112	111	113	107
103	103	110	111	103	108	110	110	113	107
103	100	103	108	102	108	104	107	104	101
101	98	96	98	102	107	100	104	102	100
100	97	93	97	95	106	99	96	98	96
98	96	92	93	94	88	94	92	95	94
93	96	90	90	93	87	93	91	91	94
93	94	82	88	88	85	93	90	86	93
88	90	82	85	81	85	90	85	83	92
87	90	79	84	80	85	86	84	81	86
85	88	76	79	79	81	78	75	75	77

Table 4: Round or oblong fruits and vegetables: frequency distribution of rate relatives, all operators and all motion patterns

Class Interval	Frequency
60-64	0
65-69	1
70-74	4
75-79	17
80-84	36
85-89	47
90-94	60
95-99	63
100-104	63
105-109	41
110-114	42
115-119	36
120-124	25
125-129	14
130-134	15
135-139	8
140-144	2
145-149	1
150-154	1
155-159	1
160-164	1
165-169	0

Table 5: Round or oblong fruits and vegetables: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio	Motion Pattern	Ratio	Motion Pattern	Ratio
MP1	2.05	MP13	1.66	MP25	2.11
MP2	1.63	MP14	1.44	MP26	1.78
MP3	2.15	MP15	2.00	MP27	1.84
MP4	1.67	MP16	1.57	MP28	1.70
MP5	1.96	MP17	1.63	MP29	1.63
MP6	1.63	MP18	1.48	MP30	1.84
MP7	1.88	MP19	1.49	MP31	1.87
MP8	1.72	MP20	1.44	MP32	1.80
MP9	1.60	MP21	1.46		
MP10	1.62	MP22	1.48		
MP11	1.79	MP23	1.42	Average	1.70
MP12	1.75	MP24	1.35		

Table 6: Bunch vegetables: rate relative for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number					
MP33	MP34	MP35	MP36	MP37	MP38
122	145	141	127	131	120
117	119	126	126	126	120
116	112	112	120	119	116
112	109	111	117	112	113
105	108	109	116	109	108
103	108	108	107	105	106
102	102	103	104	100	103
100	99	99	103	100	102
96	95	98	96	99	99
96	94	95	93	97	99
95	93	94	92	94	99
94	92	93	89	87	95
94	92	86	88	85	88
94	87	82	83	85	80
83	77	78	75	82	78

Table 7: Bunch vegetables: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	0
70-74	0
75-79	4
80-84	5
85-89	8
90-94	12
95-99	15
100-104	11
105-109	11
110-114	6
115-119	7
120-124	4
125-129	4
130-134	1
135-139	0
140-144	1
145-149	1
150-154	0
155-159	0
160-164	0
165-169	0

Table 8: Bunch vegetables: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio
MP33	1.48
MP34	1.88
MP35	1.81
MP36	1.68
MP37	1.60
MP38	1.55
Average	1.66

Table 9: Eggs: rate relatives for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number								
MP39	MP40	MP41	MP42	MP43	MP44	MP45	MP46	MP47
122	122	129	128	123	113	115	116	113
114	115	116	117	119	111	111	115	112
112	108	109	116	116	111	110	108	106
106	108	108	113	112	110	109	106	106
105	106	105	105	107	109	106	106	106
105	106	103	103	103	109	105	105	105
104	105	102	102	102	108	104	104	104
102	103	102	99	101	98	102	102	102
97	101	99	98	96	98	100	98	100
95	97	97	98	96	98	98	96	98
93	93	96	96	93	94	95	95	93
92	92	95	95	92	90	95	93	92
91	92	94	95	91	90	93	92	92
90	87	85	84	90	89	90	90	90
85	81	79	76	80	86	80	84	90

Motion Pattern Number								
MP48	MP49	MP50	MP51	MP52	MP53	MP54	MP55	MP56
119	122	119	123	136	132	128	120	133
112	119	116	112	118	115	106	118	123
112	115	110	112	117	109	104	111	117
106	110	106	110	108	108	104	108	111
105	108	105	107	105	105	103	107	107
103	107	104	102	102	103	101	106	104
100	102	101	101	101	100	101	103	102
100	102	101	100	99	98	100	101	101
100	98	101	99	99	96	99	95	100
96	96	98	97	95	95	97	94	99
93	91	92	95	95	95	95	93	99
93	89	91	94	94	94	95	89	94
92	83	90	93	91	94	92	88	86
91	81	90	91	85	89	92	82	85
89	--	88	85	81	84	92	--	72

Table 10: Eggs: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	0
70-74	1
75-79	2
80-84	10
85-89	15
90-94	47
95-99	47
100-104	49
105-109	43
110-114	22
115-119	19
120-124	7
125-129	3
130-134	2
135-139	1
140-144	0
145-149	0
150-154	0
155-159	0
160-164	0
165-169	0

Table 11: Eggs: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio	Motion Pattern	Ratio	Motion Pattern	Ratio
MP39	1.44	MP46	1.37	MP53	1.57
MP40	1.50	MP47	1.26	MP54	1.40
MP41	1.63	MP48	1.34	MP55	1.46
MP42	1.68	MP49	1.50	MP56	1.85
MP43	1.54	MP50	1.35		
MP44	1.32	MP51	1.45	Average	1.49
MP45	1.45	MP52	1.69		

Table 12: Cans: rate relatives for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number								
MP57	MP58	MP59	MP60	MP61	MP62	MP63	MP64	MP65
124	118	117	122	134	117	120	125	131
117	110	116	115	119	116	117	120	125
115	109	115	112	118	113	116	116	121
115	109	114	112	113	111	111	111	120
113	108	111	111	110	109	111	109	117
112	107	106	107	109	108	105	109	114
106	105	106	105	99	107	105	105	112
102	105	102	102	98	106	103	96	107
100	102	97	101	95	104	99	95	97
93	102	94	98	94	96	98	95	97
91	99	92	94	94	92	96	94	93
90	96	90	92	90	91	93	91	86
84	88	89	90	89	89	86	90	83
83	83	85	83	84	86	85	88	81
81	78	83	77	82	76	78	79	67

Motion Pattern Number									
MP66	MP67	MP68	MP69	MP70	MP71	MP72	MP73	MP74	MP75
125	120	127	135	131	129	128	129	140	123
125	119	120	119	127	112	127	128	119	123
113	115	118	119	114	109	113	116	118	120
112	107	113	107	110	109	112	113	118	117
111	106	109	106	110	108	112	108	113	115
111	106	109	105	105	108	106	105	111	106
105	100	106	104	102	107	101	104	102	101
104	99	104	104	101	105	100	102	98	101
102	98	101	103	100	98	99	101	97	101
96	96	95	99	98	95	94	99	97	100
95	96	94	99	97	94	94	96	94	93
90	95	92	90	95	92	91	93	94	91
87	89	89	87	86	90	88	89	90	88
83	88	78	82	85	90	82	78	86	81
74	84	76	75	73	77	81	73	66	73

Table 13: Cans: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	2
70-74	4
75-79	10
80-84	16
85-89	21
90-94	36
95-99	37
100-104	30
105-109	43
110-114	32
115-119	27
120-124	11
125-129	11
130-134	3
135-139	1
140-144	1
145-149	0
150-154	0
155-159	0
160-164	0
165-169	0

Table 14: Cans: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio	Motion Pattern	Ratio	Motion Pattern	Ratio
MP57	1.53	MP64	1.59	MP71	1.67
MP58	1.51	MP65	1.94	MP72	1.57
MP59	1.42	MP66	1.68	MP73	1.76
MP60	1.58	MP67	1.43	MP74	2.12
MP61	1.64	MP68	1.67	MP75	1.68
MP62	1.54	MP69	1.79		
MP63	1.54	MP70	1.79	Average	1.66

Table 15: Jars: rate relative for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number						
MP76	MP77	MP78	MP79	MP80	MP81	MP82
126	119	130	122	123	124	122
123	118	116	122	122	109	119
120	117	116	118	114	109	118
117	117	115	114	111	107	118
111	114	113	113	110	107	114
108	111	104	113	106	106	104
103	107	102	112	104	104	99
103	102	100	107	103	99	97
101	100	100	99	102	99	96
97	97	98	98	96	97	96
95	92	96	96	96	97	95
93	91	95	88	89	95	91
90	87	92	86	85	92	91
81	81	78	80	83	85	84
69	77	77	72	80	84	80

Table 16: Jars: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	1
70-74	1
75-79	3
80-84	8
85-89	6
90-94	8
95-99	21
100-104	14
105-109	9
110-114	12
115-119	12
120-124	8
125-129	1
130-134	1
135-139	0
140-144	0
145-149	0
150-154	0
155-159	0
160-164	0
165-169	0

Table 17: Jars: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio
MP76	1.82
MP77	1.70
MP78	1.70
MP79	1.70
MP80	1.53
MP81	1.48
MP82	1.52
Average	1.64

Table 18: Bottles: rate relatives for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number						
MP83	MP84	MP85	MP86	MP87	MP88	MP89
118	120	119	122	125	130	125
117	120	117	118	114	115	117
114	118	114	117	114	114	113
114	117	109	116	109	114	113
108	113	109	113	108	108	112
106	111	108	109	107	103	111
104	104	103	108	106	103	105
103	98	102	105	105	102	102
98	96	101	99	102	99	99
98	94	96	96	96	99	99
97	94	96	92	95	97	98
96	91	95	86	92	96	86
94	89	85	86	87	94	86
82	86	84	86	87	82	83
74	76	83	77	76	72	79

Table 19: Bottles: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	0
70-74	2
75-79	4
80-84	5
85-89	10
90-94	7
95-99	20
100-104	11
105-109	15
110-114	14
115-119	11
120-124	3
125-129	2
130-134	1
135-139	0
140-144	0
145-149	0
150-154	0
155-159	0
160-164	0
165-169	0

Table 20: Bottles: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio
MP83	1.60
MP84	1.58
MP85	1.43
MP86	1.58
MP87	1.64
MP88	1.81
MP89	1.57
Average	1.60

Table 21: Bags: rate relatives for each of 15 operators performing each motion pattern. Average normal performance time for all 15 operators is 100.

Motion Pattern Number							
MP90	MP91	MP92	MP93	MP94	MP95	MP96	MP97
126	137	113	127	125	121	139	118
119	118	112	120	117	120	127	114
117	115	111	115	116	113	117	111
114	113	111	114	112	108	114	108
113	111	108	113	109	108	110	107
108	109	105	108	104	107	108	102
105	104	104	107	100	107	101	101
103	102	102	107	99	105	101	99
99	101	101	95	97	104	101	99
98	99	100	94	97	99	99	94
96	95	96	93	97	95	98	87
86	89	95	92	97	87	84	76
86	83	88	88	88	86	83	--
82	82	84	83	86	83	80	--
78	76	83	75	78	81	76	--

Table 22: Bags: Frequency of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	0
70-74	0
75-79	6
80-84	11
85-89	10
90-94	4
95-99	19
100-104	16
105-109	17
110-114	16
115-119	9
120-124	3
125-129	4
130-134	0
135-139	2
140-144	0
145-149	0
150-154	0
155-159	0
160-164	0
165-169	0

Table 23: Bags: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio
MP90	1.61
MP91	1.79
MP92	1.36
MP93	1.70
MP94	1.82
MP95	1.50
MP96	1.82
MP97	1.55
Average	1.64

Table 24: Boxes: rate relatives for each of 15 operators performing each motion pattern. Average performance time for all 15 operators is 100.

Motion Pattern Number								
MP98	MP99	MP100	MP101	MP102	MP103	MP104	MP105	MP106
132	124	119	127	120	117	123	124	115
122	119	115	122	116	117	123	122	112
119	114	114	119	116	114	119	112	110
116	111	113	118	107	109	111	108	109
109	105	111	105	107	105	110	107	109
105	103	107	103	104	104	104	106	109
105	102	106	100	103	100	102	102	105
104	102	99	99	98	100	100	102	97
103	101	97	98	98	98	96	97	96
99	101	96	97	98	98	96	95	96
97	97	94	94	94	95	93	93	96
92	95	93	93	94	95	93	92	96
89	92	93	88	90	89	87	90	92
83	86	88	85	87	89	85	87	86
66	72	76	78	83	84	82	83	85

Table 24: (Cont.) Boxes: rate relatives for each of 15 operators performing each motion pattern. Average performance time for all 15 operators is 100.

Motion Pattern Number								
MP107	MP108	MP109	MP110	MP111	MP112	MP113	MP114	MP115
119	117	125	125	121	120	115	117	111
116	117	114	122	120	115	114	115	110
113	105	111	116	118	114	114	114	109
111	105	103	114	118	111	109	114	109
108	103	101	109	116	104	109	106	106
105	103	101	105	110	103	109	104	103
103	101	100	104	101	103	108	102	99
102	99	99	98	101	103	99	98	98
99	97	98	95	94	99	98	96	95
98	97	97	86	89	93	98	95	94
94	97	95	84	80	90	87	85	90
89	96	94	72	69	69	67	74	85
89	96	92	—	—	—	—	--	—
86	92	90	—	--	--	--	—	—
84	84	84	—	—	—	--	--	--

Motion Pattern Number			
MP116	MP117	MP118	MP119
130	147	129	145
121	134	123	135
111	107	111	115
107	104	104	99
103	101	104	96
102	100	102	95
102	99	98	94
102	99	95	94
91	91	94	93
88	90	89	89
88	85	88	88
78	79	84	88

Table 25: Boxes: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
60-64	0
65-69	4
70-74	3
75-79	4
80-84	11
85-89	29
90-94	33
95-99	57
100-104	48
105-109	34
110-114	27
115-119	26
120-124	14
125-129	4
130-134	3
135-139	1
140-144	0
145-149	2
150-154	0
155-159	0
160-164	0
165-169	0

Table 26: Boxes: ratio of slowest operator to fastest operator, each motion pattern.

Motion Pattern	Ratio	Motion Pattern	Ratio	Motion Pattern	Ratio
MP98	1.99	MP106	1.36	MP114	1.57
MP99	1.72	MP107	1.43	MP115	1.31
MP100	1.56	MP108	1.39	MP116	1.66
MP101	1.63	MP109	1.50	MP117	1.87
MP102	1.44	MP110	1.73	MP118	1.54
MP103	1.39	MP111	1.74	MP119	1.66
MP104	1.50	MP112	1.73		
MP105	1.50	MP113	1.71	Average	1.59

Table 27: Summary of all commodity groups: frequency distribution of rate relatives, all operators and all motion patterns.

Class Interval	Frequency
65-69	8
70-74	15
75-79	50
80-84	102
85-89	146
90-94	207
95-99	279
100-104	242
105-109	213
110-114	171
115-119	147
120-124	75
125-129	43
130-134	26
135-139	13
140-144	4
145-149	4
150-154	1
155-159	1
160-164	1

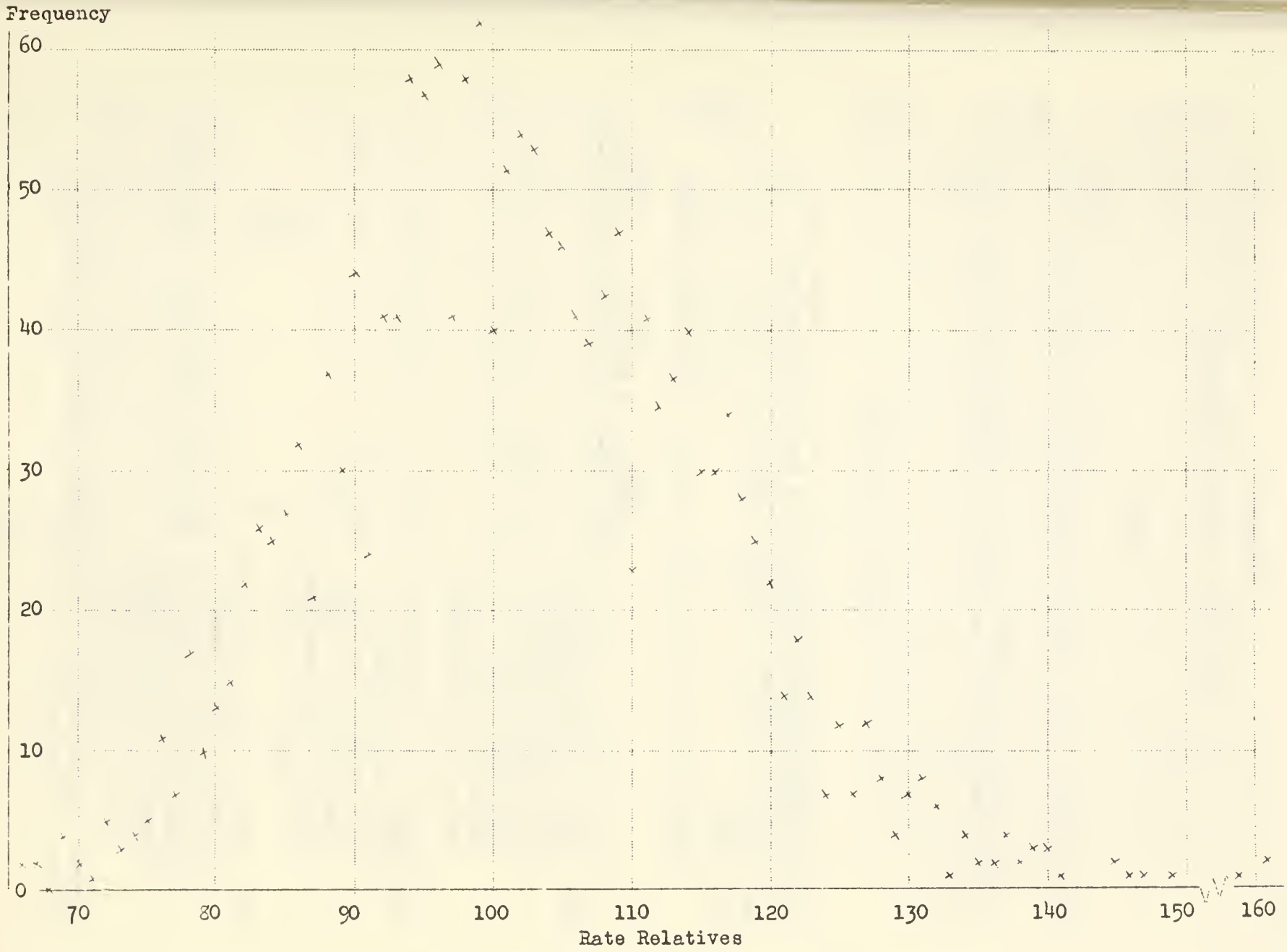

Figure 1. Frequency Distribution of All 1,748 Rate Relatives

CHAPTER XII

APPLICATION TESTS AND TECHNIQUES

Tests

In order to make a test of the table data, two work operations were selected. One of these was layer packing apples; the other was stocking grocery shelves with canned goods.

The comparisons between the test data and table data are based on relationships rather than absolute time values. A single person is likely to work at a considerably different pace than the average pace of 15 persons.

Layer Packing Apples

The data collected from a worker in an apple packing plant is compared with the table values for the same motion patterns. The table data is combined into get and place for comparison. It will be noted that the ranking is the same for the test operator as for the table data.

Motion patterns 15 and 16 are commonly used in layer packing

		GET		PLACE		CYCLE	
		Test	Table	Test	Table	Test	Table
MP15	Apples. Single grasp of one. From jumbled on flat surface. Move to single tilt crate. Single position-release. Side reach and move 24".	25	20	40	29	64	49
MP16	Apples. Simo grasp of two. From jumbled on flat surface. Move to single tilt crate. Consecutive position-release. Side reach and move 24".	38	28	65	60	104	88
MP19	Apples. Simo grasp of two per hand. From jumbled on flat surface. Move to double tilt crate. Consecutive position-release. Side reach and move 24".	45	35	108	79	153	114

apples. Motion pattern 19 is an improved method which was worked out during this project.

Motion pattern 16 took 80 percent longer per cycle than motion pattern 15, according to the table data. One would predict that approximately the same relationship might exist in the data of the test operator. Actually the test operator took 62 percent longer for motion pattern 16 than for motion pattern 15. Motion pattern 16 is the more efficient motion pattern of the two, because twice as many apples are handled per cycle.

Motion pattern 19 took 133 percent longer per cycle than motion pattern 15, according to the table data. If one predicted the same relationship for the test operator, he would be only six percent off. The test operator took 139 percent longer per cycle for motion pattern 19 than for motion pattern 15.

The relative efficiency of these motion patterns is shown more clearly when the time per apple is computed. One, two, and four apples respectively are handled when performing motion patterns 15, 16, and 19.

		Time Per Apple Packed	
		Test	Table
MP15	One hand single grasp	64	49
MP16	One hand simo grasp	52	44
MP19	Two hand simo grasp	38	28

In both of the first two patterns, the worker had to hold the fruit in position in the layer with the left hand. For motion pattern 19, a packing stand was used which lifted the far end of the crate (end farther from the packer) and also the outer edge of the crate. This formed a double tilt. When fruit was placed in the crate, starting in the lowest corner, it stayed in position by gravity. Both hands could be used for constructive work. This gave a substantial increase in output over the other two motion patterns.

The skill requirements of these motion patterns provide another basis for appraising these three alternative motion patterns. Motion

	Get	Place	Cycle
MP15	72	71	71
MP16	80	78	78
MP19	79	78	78

pattern 15 had the lowest skill requirement of the three. This would be anticipated since only single grasps and single position-releases were employed. However, motion pattern 15 is too poor on a time basis for serious consideration. The other two motion patterns show the same average skill requirements. Since motion pattern 19 is far superior on a time basis, its choice is clearly indicated.

Stocking Shelves with Canned Goods

The data collected from a worker in a grocery store is compared with the table values for the same motion patterns. The table data is combined into get and place for comparison. It will be noted that the ranking is the same for the test operator as for the table data.

		GET		PLACE		CYCLE	
		Test	Table	Test	Table	Test	Table
MP60	Not oriented. 303 can. Two hand single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18".	26	32	36	38	62	70
MP69	Oriented. 303 can with ordinary label. Two hand single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18".	26	32	49	61	75	93
MP67	Oriented. 303 can with 2 sided label. Two hand single grasp of one can per hand. From case. Move to shelf. Single position-release. Front reach and move 18".	27	32	42	46	69	78

Motion pattern 60 did not include orienting can labels to face customers; whereas, motion pattern 69 did. Motion pattern 69 took 33 percent longer, according to the table data. The test operator took 21 percent longer to perform motion pattern 69 than he did for motion pattern 60. There is some difference between the test operator data and the table data, but both indicate that motion pattern 69 requires substantially more time to perform.

Motion pattern 69 and motion pattern 67 both involve orienting can labels to face customers, but motion pattern 67 was done with cans having two-sided labels. The table data showed that it took 16 percent less time per cycle to handle the cans having two-sided labels. The test operator took only eight percent less time per cycle when handling the cans having two-sided labels. Both show that the two-sided label is decidedly superior to the ordinary can label on a performance time basis.

The skill requirements provide another basis for appraising these motion patterns. Motion pattern 67 required substantially less skill

	Get	Place	Cycle
MP67	72	64	67
MP69	74	70	71

than motion pattern 69 as well as less time to perform. Its choice is indicated clearly on both a time and a skill basis.

The reduction in skill requirements for motion pattern 67 was mainly in the place portion of the cycle. That is the part where orienting the labels takes place. The two-sided label required much less turning in order to present a label face toward customers.

Conclusions

One would not expect the relationships of data from a single test operator to correspond precisely with the table data. However, they were nearly enough alike in the above tests to indicate consistently the same choice of motion patterns. This might not be true if two motion patterns were rather close together in time requirements. In that case, however, there would be relatively less importance in the choice.

Technique of Applying Table Data

The table data was obtained from the handling of a rather wide range of different commodities, and many different motion classes were used in the handling of these commodities. In instances where data is wanted for a commodity and motion classes which were included in the tables, such data can be taken directly from the tables. Effective motion patterns can be easily located.

Many commodities which were not included in the tables are quite similar to those which were. (See Chapter X, "Classification of Products.") The table data can be projected to cover these with relative safety.

Similarity of commodities in outward appearance is not always of key importance. When one becomes familiar with the skill characteristics and their effect on work performance, reasonably good estimates can be made from the table data for the handling of objects which are quite different from those upon which the specific table data are based.

The specific use of these tables is for selecting the best from among several alternative motion patterns. In a large plant, some workers may be so highly specialized that one motion pattern

constitutes their entire job. Ordinarily this will not be true. However, in ordinary circumstances a very few different motion patterns may make up a large proportion of one person's total work.

If one's job were the grading and packing of eggs, there would be two relatively important motion patterns and several of lesser importance. The two important ones are (1) loading the egg grader, and (2) packing eggs. These two are important because they are highly repetitive, thus requiring a large proportion of the total working time. In both of these cases, a highly effective motion pattern can be taken directly from the tables.

In the total task of grading and packing eggs, there are several motion patterns of considerably less importance than the two mentioned above. These are not all included in the tables; but, in most cases, fairly good estimates can be made of their time requirements from the table data. In order to show how the table data might be used for estimating the time requirements of a specific task, data will be derived from the tables for each of the motion patterns used in grading and packing a case of eggs. Making performance time estimates is not the purpose of these tables, but the table data can be used for that purpose.

A motion pattern for loading the egg grader can be chosen directly from the tables. There are several different motion patterns for loading an egg grader included in the tables, but motion pattern 43 appears to be the best choice. It requires 107 winks per cycle. Since there are 360 eggs in a case and each cycle loads four eggs on the grader, 90 cycles will be required to grade one case of eggs. The 90 cycles at 107 winks per cycle would require a total of 9,630 winks. In making this estimate, a distance of 12 inches for reaches and moves is assumed.

A motion pattern for packing eggs into the case can also be chosen directly from the tables. There are several different motion patterns for packing eggs included in the tables, but motion pattern 50 appears to be the best choice. It requires 101 winks per cycle. Since there are 360 eggs in a case and each cycle packs four eggs in the case, 90 cycles will be required to pack one case of eggs. The 90 cycles at 101 winks per cycle would require a total of 9,090 winks. In making this estimate, a distance of 12 inches for reaches and moves is assumed.

In loading the egg grader, one has to set aside an empty egg basket occasionally and get a filled one. This element would occur about two times per crate.

No motion pattern in the tables involves handling an empty egg basket. Setting aside an empty egg basket would require no orienting and no precise positioning. Moving a couple of cabbage to a display bin without orienting or positioning them would be about the same order of skill and should not be too far removed in time requirements.

Motion pattern 29 is selected for this estimate. It requires 77 winks per cycle. Since this element would occur about two times per crate, the total time required for it should be about 154 winks. A distance of 36 inches was assumed for this element.

Getting a filled basket of eggs should correspond fairly closely to moving a 25-pound box an equal distance, but about 10 percent was added to the time because the eggs are fragile and must be set down carefully. Moving a 25-pound box 36 inches (motion pattern 117) requires 85 winks per cycle. Adding 10 percent would make this 94 winks and, since the element would occur twice, the total time should be about 188 winks.

The element of putting in a flat was not included in the tables, but it corresponds fairly closely in amount of control required to moving a half pound box in each hand to a shelf and positioning them on the shelf. A distance of 36 inches is assumed. This operation is represented by motion pattern 100 which requires 89 winks per cycle. Since there would be 12 flats put in per case, the total time required would be 1,068 winks.

The element of putting in fillers was not included in the tables either, It requires about the same amount of control as putting in flats. The same distance (36 inches) is assumed and the same motion pattern (MP100) used for estimating. There are ten fillers to the case, so the total time for this element should be about 890 winks.

When packing eggs, ordinarily half of the case projects from under the grader bin. When that half is filled, the case must be turned. This element of "turn case" will be rather difficult to estimate. Boxes of about the same weight were handled, but the egg case is often fitted very closely between two other egg cases and also it is usually only a fraction of an inch below the bottom of the grader bin. Motions made in such restricted areas require enormously more time to complete than the same motion made without restriction. The egg case only has to be moved out about 36 inches, turned, and moved back about 36 inches. One cycle of moving a 25-pound box 36 inches (MP117) is used to correspond to moving the egg case out, another cycle is used to represent turning the egg case, and a third cycle is used to represent putting the reversed egg case back in position. Motion pattern 117 requires 85 winks, so the total element is estimated to be about 255 winks long.

Stop watch data was available in the laboratory for each of the elements used. The summary below shows how the average of eight persons timed by stop watch on actual operations compares with

Element	Table Data Estimates (Minutes)	Stop Watch Data (Minutes)
a. Load egg grader	4.81	9.36
b. Pack eggs	4.54	
c. Set aside empty egg basket	.08	.28
d. Get full egg basket	.09	
e. Put in flats	.53	1.33
f. Put in fillers	.44	
g. Turn case	.13	.40
	10.62	11.37

estimates synthesized from the table data. The first two elements were the only ones directly included in the tables and they compare very closely with the stop watch value. The estimates of the other elements generally run somewhat less than the corresponding stop watch value. That is not altogether a discrepancy. The layouts used by some of the eight operators timed by stop watch were very poor. Distances to put aside an empty egg basket and get a filled one, and also distances to fillers and flats, were often excessive. Ordinary distances were assumed in making the estimates from the table.

The discrepancy involved in the element "turn case" cannot be explained by poor layout. It was an unusually difficult motion pattern to estimate. No motion pattern with such restrictions was included in the table, and guessing did not give a very accurate answer. In a case such as this, a better solution would be to duplicate the motion pattern and time it.

The estimated data agrees with the stop watch data fairly well. If time is limited, making estimates of performance time such as the above may be useful.

CHAPTER XIII

PHOTOGRAPHIC TECHNIQUES AND EQUIPMENT ADAPTED TO WORK METHOD ANALYSIS

Motion pictures are quite useful for three distinctly different phases of work method analysis. These phases are: (1) motion study, (2) collection of time data, and (3) worker training.

In motion study the objective is to learn just how the motion pattern is performed. Only very short lengths of film are needed, so film cost is not a big problem. One needs a very sharp, high quality image. Slow-motion speeds are often helpful in recording more detail.

Recording time data is a quite different objective. One who is collecting data will not study the film in as much detail as he would in motion study. He cannot because he would never obtain sufficient data if he worked so slowly. The quality of image can be somewhat lower and still be satisfactory for this purpose. Large volumes of film will be used and economies in purchasing more worthwhile. Expedients such as negative film are practical means of reducing cost. Even with such expedients, data collected on motion picture film is far superior to data collected by other means, because the film records the motion pattern as well as the time. Undesirable deviations can be eliminated in film analysis which would never be detected in stop watch work. Furthermore, the record of the motion pattern is permanent and apparent deviations in the data can be rechecked.

A third use of film is the training of workers. Motion pictures have not been used as freely for this purpose as they should, because people who need films have felt that a training film should be modeled after a professional motion picture production. Simple, straight-forward motion pictures have proved to be more satisfactory for training purposes. Professional tricks and effects do not improve the effectiveness of training films (see Chapter XIV, "Instruction Methods").

In all phases of work method analysis, one should realize that his objective is different than for conventional motion picture making. He should not permit quality standards set for conventional motion pictures to hamper his work. A few scratches on a film, a smear, or finger print are of little consequence to a work method analyst. They are disastrous to other motion picture makers. Professional effects such as extreme closeups, fades and dissolves, wipes, and even titles are usually a waste of time in work method analysis. They are the stock-in-trade for makers of conventional motion pictures. The conventional movie maker is justified in continual experimenting for artistic effects. The work method analyst should seek an efficient standard procedure which interferes the least with the other duties he must perform.

The Camera

Almost any motion picture camera on the market is capable of producing films suitable for work method analysis. Some have limitations which make them poorly suited for any considerable volume of such work. Several features need to be considered before purchasing a camera, particularly if the budget is limited.

Film Size

The 16 mm. film size has become standard for motion study and worker training. It is cheaper than 35 mm. and provides a perfectly satisfactory image. The 8 mm. is worth considering for data collection. It is considerably cheaper than 16 mm. and provides very good image definition. The chief difficulty with 8 mm. is that time study projectors have not been available in that size and such film does not permit as detailed examination of the motion patterns.

Practically all of the material in this chapter refers to 16 mm. equipment and to black and white film.

Magazine Vs. Reel Loading

Magazine cameras are easier and faster to load than reel loading cameras. A partially used magazine may be taken out of the camera and a full magazine inserted. The partially used magazine can be reinserted later and used up. This feature permits short lengths of film to be used more effectively than in reel loading cameras. If a long run is needed with a reel loading camera, a short piece in the chamber must usually be sacrificed in order to reload. On the other hand, magazines come in 50-foot lengths only (16 mm.); whereas, reel loading cameras take 100-foot spools and can be obtained for 200-foot, 400-foot and even larger capacity. Consequently, the reel loading cameras have less short ends to deal with.

Film in factory loaded magazines costs considerably more per lineal foot than film in reels. This extra cost can be avoided by buying film in bulk and spooling the magazines. This is extra work, however, and would not be worthwhile except where a large volume of film is to be used.

The magazine cameras generally cost considerably less than reel loading cameras of similar quality. This point should not be given too much importance, especially if factory loaded magazines are to be used. The difference in the cost of magazine film and spool film can quickly use up the savings made on the camera.

The magazine camera is less bulky than the reel loading camera. Whether this is important or not will depend upon the use contemplated. A light magazine camera can do excellent work and is very convenient to handle where only short lengths of film are to be

taken. It serves very nicely for straight motion study. It is not so well adapted for collection of motion data.

Camera Drive

Only the higher priced cameras have spring motors which are consistent enough in speed of operation to use for timing by frame count. If a clock is placed in the picture area, variations in camera speed make little difference. Even with the more expensive machines a clock is advisable so that speed can be checked from time to time.

There are two types of electric motors used for camera drive: the synchronous and the non-synchronous. The former is the most accurate for timing. It is the same type of motor that is used in electric clocks. When it is used on a camera the frame count will correspond precisely with times read from a clock which was photographed. The non-synchronous motor costs considerably less and is sufficiently accurate for most purposes. Several cameras have or may be equipped with electric motor drive: namely, Kodak Cine Special, Bolex, Bell and Howell Filmo 70, Bell and Howell Filmo Electro, and others. The Lafayette Instrument Company makes a synchronous motor drive for the Kodak Cine Special and for the Bolex H 16. These drives operate at three speeds: 10 frames per second, 1000 frames per minute, and one frame per second. The one frame per second is called memomotion and gives a shutter speed of 1/25 second.

Longer interval timers are available for the Bolex camera from the Stevens Engineering Company, Los Angeles, California. This device will operate both the camera and lights at intervals of up to 30 minutes between successive shots.

Ultra high speed motion picture photography can be accomplished with machines such as the Wollensak Fastax which operates at speeds from 150 frames per second to 14,000 frames per second. The ultra fast machines have little application in the study of motions made by the human body but are frequently found to be quite useful in studying malfunctions of fast moving machine parts.

Camera Shutter

Ordinarily the exposure time of a motion picture camera is about 1/2 of the time per frame. A camera operating at 16 frames per second would use 1/16 second per frame. The shutter is only open for approximately one half of that time. Consequently, the shutter speed is about 1/32 of a second. Different makes of cameras vary slightly from this.

Some of the more expensive cameras such as the Kodak Cine Special and Pathe have variable shutters. The shutter speed can be increased without changing the number of frames per second. With the variable shutter 1/2 open at 16 frames per second the shutter speed would be about 1/64 of a second instead of 1/32. With the variable shutter at one quarter open the shutter speed is 1/128 of a second. This feature permits the camera to stop very fast action without the usual blur. It is not as useful in motion study as might be expected. The blurred image of the ordinary shutter speed serves two purposes. It indicates the direction of movement and it is helpful in locating break points when analyzing film. No extra money should be spent in order to have this feature unless some special use warrants it. Ordinary motion analysis does not.

Lenses

The three principal characteristics of a lens are: focal length, speed, and resolving power.

The focal length of the lens indicates the width of field covered. The short focal length lens is called a wide angle lens. The long focal length lens is called the telephoto lens. In between is the "regular" lens. A complete set of all three could be classified as "nice to have." The wide angle lens is by far the most useful. For motion study one can hardly feel handicapped if he has no other lens than a good wide angle. Furthermore, the wide angle lens is likely to be the least expensive. It is usually easy to move in close with the wide angle lens so that only the proper area is photographed. It is often impossible to move back far enough for the regular or telephoto lens because of walls or other obstructions. Furthermore, a high camera angle is very frequently desirable. Six or seven feet may provide this angle with the wide angle lens; whereas, much higher camera positions are necessary with the other lenses to give the same perspective. Mounting a camera higher than six or seven feet can be very difficult. It is estimated that no more than five percent of the work will be done with the other lenses even if they are readily available.

In comparison to still cameras, virtually all motion picture camera lenses would be classified as fast. The slowest is usually about f 2.8. This coupled with the fact that motion picture shutter speeds are slow does not indicate any great need for an ultra fast lens. It is sometimes convenient, but seldom necessary. However, due to the great depth of field of these lenses, a fast lens can be used wide open without serious fuzziness. The whole picture area will usually be in reasonably good focus. The fast lens will permit the use of less light, or the use of a film with slower emulsion speed. Both are worthwhile advantages.

A lens in a focussing mount is more desirable than the fixed focus type. The fixed focus lens is simply set permanently for one average distance and depends on depth of focus to provide adequate

sharpness for other distances. A focussing lens set by estimate will maintain a much better focus. If a large volume of work is to be done at a fixed distance, this distance can be set on the focus ring and the ring taped with scotch tape so that it does not move. Thus, precise focus is obtained as well as the convenience of fixed focus. If distances vary from shot to shot it is a good idea to measure with a tape occasionally. This helps to keep the estimates in line. Range finding gadgets are not needed.

A good lens will have a high resolving power; i.e., it will produce a sharply defined image. However, one need not worry too much about lens quality for methods work. Most lenses on the market, including the moderately low-priced ones, are good enough. If pictures lack definition, there are several sources of trouble which are more likely to be at fault than the lens. Among these are film used, tripod, and exposure.

Viewfinder

The viewfinder will give very little trouble except when one works close to the edge of the field. Then there is danger of chopping off a vital part of the subject. The reason for this is called parallax. The viewfinder image and the image registered upon the film are not the same. This discrepancy can be troublesome in making films for motion study, since it is desirable to have as large an image as possible for film analysis. The reflex finder, which receives its image through the taking lens, shows precisely the same image as will be recorded on the film. This finder allows one to make the maximum use of the picture area.

A cross-hair reticle in the reflex finder is a great convenience. Once the desired composition is attained, an aiming point can be put up. Thereafter, the same composition can be reproduced by simply putting the cross hair on the aiming point, assuming that the tripod has not been moved. It may be desirable to mark on the floor the tripod position if very much film is to be exposed from the same camera position.

Camera Case

The camera case is a desirable piece of equipment. It protects the camera from bumps and reduces the dust which will foul the lens and mechanism. It is also a handy place to keep accessories. If the budget is slim, a good enough case can be made of plywood.

Film

The important characteristics of motion picture film are: grain size, emulsion speed, and price. One cannot find the optimum

of all three of these in one film. Consequently, one must determine which of the film emulsions best suits his particular needs.

Detailed Motion Study

The best film for this purpose will be a fine grain emulsion, and fine grain emulsions are only moderately fast. The fine grain moderate speed films are the best choice for all ordinary motion study.

Poor Light Condition

A high speed film must be chosen where poor light is a necessary condition. High speed is a highly desirable characteristic, but it is accompanied by enlarged grain size. The images are not as clearly defined. The film is more flexible in its use because less artificial lights are required. If the level of illumination is high the lens may be stopped down to a smaller opening. This increases the depth of the field which will be in sharp focus.

The lighting equipment which is bulky and time consuming in setting up can be held to a minimum. Still the large grain size reduces the quality of image to such an extent that fast film should not be used where it is practicable to obtain enough light for the fine grain emulsions.

Economy

There seems to be only one satisfactory way of reducing film costs; i.e., by doing your own processing, but only in some instances will such savings justify the labor involved. Surplus and outdated films are on the market, but the other expenses involved in making films for motion study are too great to risk using them.

Reversal Processing

Reversal processing is somewhat difficult and much too time consuming for ordinary users. If the volume handled warrants the purchase of the very expensive processing machines, then reversal processing can be practical. These machines cost several thousand dollars. Satisfactory work can be done with the amateur equipment, but the process requires too much time.

Negative Processing

Although it calls for some adjustment in one's thinking, perfectly good motion analysis can be done from negatives. The negative

films do not include processing in the film price as do most reversal films. The price is about 40 percent of the cost of reversal film. Processing is simple and quick. A still greater saving can be made by using bulk film and spooling it prior to use.

Fine grain positive film is the lowest priced of all motion picture films. It is a very slow film made for the purpose of printing duplicates of motion picture films from a negative film. It is sensitive to blue light only, but there is a large proportion of natural outdoor light which is blue and a considerable amount of indoor artificial lighting also is blue. By extreme overdeveloping, this film can be used satisfactorily for camera speeds up to 16 frames per second. It appears to stand overdeveloping better than other emulsions. More light is needed for this film and a very fast lens is highly desirable. The cost, including a reasonable amount for developing chemicals, is less than a cent a foot. For outdoor work, the speed of this film is high enough that it offers no particular difficulty. For indoor work, extra lights are needed and key points should be painted in white or white tape stuck on. Backgrounds should be white so as to provide dark image on film. Too light an image has too much glare for analysis.

Color Film

There is no advantage in using color film, but there are two serious disadvantages. It is too expensive and the emulsion speed is slow. Even when films are made for the purpose of demonstrating a work method, there is no particular advantage in using color. Perhaps the scenes might be prettier, but beauty is not the objective of training films. It seems more likely that color distracts attention from the main purpose.

Film Processing

The chief reason for doing your own processing is to cut down the cost of film. In using negative film the cost is reduced to less than half. Fine grain positive film is less than one quarter the cost of factory processed reversal. There are other advantages to doing self-processing. When film is mailed to a processor, there is a wait of a few days before it is returned. This usually means that quite a large volume of film will be shot before the first reel is inspected. This situation is seldom drastic, but worthwhile improvements in the photography can be made after inspecting the results; if the results can be seen early enough. In doing the processing, the effective emulsion speed of the film can be adjusted by overdeveloping. Processing increases one's knowledge of photography, and finally, the work of processing can sometimes be done in slack periods at little or no extra cost for labor.

Reversal Processing

Ordinarily the price of motion picture film includes a charge for processing. If only a small volume of film will be used, the best plan is to use a regular reversal film and send it to a processor. Reversal processing can be done very well by the user, but some of the reversal chemicals do not keep well and the reversal process is costly in time. Both the chemical formulas and the procedure for reversal processing can be obtained from Ansco, Dupont or Superior.

Negative Processing

This is the same simple procedure used for developing any ordinary still camera film. The procedure consists of developing, fixing, washing, and drying.

Developing: Several different types of developing tanks are available for processing 16 mm. motion picture film. The Stineman and Watson tanks use a core somewhat like those used in 35 mm. tanks. The Calumet uses a rack, around which the film is wound, and a deep tank. The Morse and Micro records use two reels submerged in the developing solution and the film is wound from one reel to the other, back and forth, through the developing solution. The Superior uses a revolving rack with the bottom of the rack submerged in a tray of developer. There are much more elaborate machines such as the Houston and Bridgomatic which do the entire process automatically. These automatic machines cost several thousand dollars while the simpler ones range from $25.00 to $225.00. Several of the least expensive models, the Morse G-3, were used on this project and found to be quite satisfactory.

There are many developer formulas which will do good work. Kodak D-76 was chosen for this project because it was readily available in prepared form and because it is rather versatile. It is a medium fine grain, low contrast developer. It is slow acting, requiring about 17 minutes for normal development in an ordinary 35 mm. film tank. By simply adding 1,040 grains of Kodalk (Kodak Balanced Alkali) per gallon, D-76 is converted into a vigorous, medium grain, medium contrast developer. Four minutes are sufficient for normal development in an ordinary 35 mm. film tank. By overdeveloping in the D-76 with extra Kodalk, the effective emulsion speed of the film can be increased 5 to 10 times its rated value. The one formula can be made to serve the different purposes simply by changing the quantity of Kodalk and the developing time. Replenisher for this formula is also available in prepared form. When extra Kodalk is used in the developer, it must also be added to the replenisher. Exact amounts and procedures for this developer and others can be obtained from Kodak Data Book "Chemical Formulas." When one is mixing developer and replenisher in gallon lots, the Kodalk can be measured accurately enough with a small measuring cup.

The cup should be about the size of a thimble and should have a wire handle soldered on. The cup is faster than scales and is perfectly satisfactory.

Developing time varies greatly with the temperature of the developing solution. One must use a thermometer. The most satisfactory method found was to maintain the room temperature at 70° F. Then a time-temperature table was developed by first checking the Kodak Data Book "Processing and Formulas." This gave a good first approximation. Then the time-temperature scale was adjusted by trial until developing times for all temperatures from 66° to 74° were filled in. This gave a good working range. Higher temperatures produce a poorer quality and lower temperatures require too much time.

Fixing: After development was completed, the film was rinsed in old hypo. Then it was fixed in Kodak Rapid Liquid Fix bath. The last hardens the emulsion and renders the image permanent. The hypo rinse and fix bath are done in the film tank. When the Kodak Rapid Liquid Fix becomes so weak that too much time is required for fixation, it becomes the hypo rinse and a new fix bath is mixed. The old hypo rinse lengthens the life of the fix bath, particularly if about an ounce of dilute acetic acid is added after every reel. It is not advisable to try to use the fix bath too long. The Kodak Rapid Liquid Fix bath in the Morse G-3 tank would do four 100-foot reels per quart by increasing the length of fix time after each reel. The time requirements per reel were consecutively: 8, 10, 12, and 14 minutes. The last reel was a little safer if about one or two ounces of fresh fix solution was used to replenish the fix bath.

Washing: After fixing, the film is unwound into a five-gallon pail or tub loosely for washing. This pail needs a few small holes in the bottom for draining. The pail is placed in the sink under the faucet and water is allowed to run slowly for about 30 minutes. This washes out the hypo. Excess water is sponged off with a viscose sponge after washing.

Drying: A wire or cord such as a clothesline is strung across the room about seven or eight feet from the floor. The film is suspended from this by ordinary paper clips bent so that they can be hooked over the line. The film is hung down in loops spaced just far enough apart to keep adjacent loops from rubbing against each other. The paper clip is bent to form a flat bottomed hook, and the film is simply placed across it emulsion side up.

Summary: The above technique for processing is crude but effective. Films processed for motion study should be clear and sharp, but an occasional scratch or smear makes very little difference. For other photographic purposes, extreme care is exerted to avoid scratches and smears. Ordinarily, it is important to keep films perfectly clean because of the impression they will make on the audience. However, motion study films are work films. They are not made for

an audience. Consequently, the time consuming care used in handling other films would be wasted on them. The acid test of motion study films is how well they serve their purpose. Do not make the mistake of using the standards for other types of motion pictures in judging motion study films.

Lighting

The action of light upon the sensitized emulsion forms the photographic image. Consequently, the effective use of lights or choice of outdoor light conditions is essential to good photography. This is true for motion study photography as well as other types.

Natural Sunlight

Sunlight has a higher actinic value than artificial lights of the same strength and is several times stronger than the pair of number 2 photofloods usually used for 16 mm. motion pictures indoors. Smaller lens openings can be used outdoors, thus increasing the depth of focus. In fact the depth of focus is increased so much that range finding is no problem. The slower film emulsions can be used. In fact they should be used, because they have finer grain. Even the fine grain positive film is fast enough when used outdoors. It is close to a color film in speed when used in sunlight.

The one greatest difficulty with outdoor lighting is its variability. This is not a serious difficulty but must be kept in mind when working in sunlight.

Occasionally an undesirable shadow will be present when photographing outdoors. A photoflood can be used to knock these out if electric power is available.

Indoor Lighting

Photofloods are the answer for indoor lighting. Frontal lighting is highly satisfactory for motion study and is much simpler than other light arrangements. Aesthetically the frontal light is not as good as an arrangement which provides side lighting and back lighting. However, the job in motion study is to make clear pictures for analysis - not pretty pictures.

If only a small volume of work is to be done, the reflector floods are excellent. These have reflectors as an integral part of the bulb. They can be positioned by means of a spring clamp (with ball and socket) holder which is available at any photographic supply store. A crossbar with one light on either side of the camera is better suited if a larger volume of work is contemplated. The latter arrangement is more convenient. The camera and the two floodlamps are all attached to this crossbar and the bar is mounted on a tripod. It is very convenient to

have lights mounted firmly. The crossbar provides this rigidity. The spring clamps do not. It is a common occurrence when using the spring clamps to have a lamp slip so that it is no longer pointed in the right direction. This may not be noticed for some time. A rigid light holder is much more satisfactory if a large volume of work is to be done. The crossbar can be purchased, but if the budget is slim, a home-made job can be done in a few minutes. Simply mount a couple of sockets on a wood cross bar.

Background

It is not always possible to control the background, but it is worthwhile to do so when conditions permit. Films made with a well designed background are easier to analyze and are easier on the eyes.

Highlights

One of the functions of the background is to avoid large areas of highlight. These areas are objectionable whether they occur as one single mass or as many small areas. The effect is similar. There will be a glare thrown off from these white areas which shocks the eyes. The pupils will react in somewhat the same manner as they would if you were looking at a naked light bulb and turning it on and off repeatedly. If the light were left on, the pupils would adjust, or if it were turned off, they would adjust. But the continual change from one to the other is very fatiguing. As the film is cranked through an analysis projector frame by frame, these highlight areas strike the eyes with uncomfortable force.

The best solution to the problem seems to be a neutral gray. Solid black would do very well as far as highlights are concerned, but its low reflecting capacity would introduce another problem. In order to have sufficient light for a good image of the key areas, the strength of the light source would have to be increased immensely. An extra photoflood or two will not be very comfortable to the person being photographed.

If negative film is used and negative images are analyzed, the background should include a very high proportion of white. This photographs as black and is easy on the eyes.

The Grid

The grid is placed on the background, and is photographed when the worker is photographed. When the film is cranked through the analysis projector, the worker's hands are seen in motion against the stationary background grid. Changes of the worker's body member in relation to a nearby portion of the grid make it certain that motion has occurred. The grid must be photographed. It does not serve its purpose as well if it is painted on the screen or projected

on screen. The reason for this is that the film transparency being projected does not stop in precisely the same spot from frame to frame. Consequently, motion may appear to take place when there was no motion. This discrepancy frequently occurs when reversing the projector.

The grid or pattern should be somewhat irregular so that each portion is distinctly different. This relieves monotony and aids in keeping body members located. The grid or pattern should be located at key points; i.e., where break points occur. Do not overdo it in other areas.

The background grid is much more effective if the operator wears contrasting arm bands, particularly on the wrists. These will show up against the background much better than the arm itself.

Exposure

There is no such thing as correct or proper exposure, except in terms of the use made of the finished film. For motion study, a reversal film which is overexposed will be too bright. It will tire the eyes. A reversal film that is underexposed will be too dark, and it will be difficult to see the necessary detail. There is also an optimum level of exposure for image definition. If this exposure does not correspond with the exposure for the best image tone mentioned above, then the value for best definition should be used. The bright images can be toned down in projection by other means (see Film Analysis below).

There are several variables involved in exposure, each of which is subject to error of measurement. The emulsion speed rating of the film represents the best representative average figure which the manufacturer is able to determine. It is not an exact figure and varies somewhat from one lot of film to another. The shutter speeds of cameras vary notoriously from the speeds indicated, particularly on some lower priced cameras. All light meters do not register precisely the same for the same light conditions. This is particularly true if the meter has been in use for some time without recalibration; but even if the meters registered the same, the quality of light can vary greatly. An indication of this characteristic is evidenced by the lower value given for emulsion speed by tungsten light than is given for outdoor light. Outdoor light quality varies tremendously, but the instructions which come with the light meter do not burden the user with that information. The ordinary meter does not show these light quality differences, anyway. Blue light has a higher actinic value, or in other words, acts more swiftly upon the photographic emulsion. Consequently, when a light meter reading is taken on a cloudy overcast day, the indicated exposure is reduced considerably. On that kind of day, blue light predominates. Furthermore, a film which projects perfectly when using a 200 watt projection bulb is too thin for use with a 750 watt projection bulb.

All of the foregoing is intended to indicate that you must set your own standard of exposure on the basis of the results you get with the equipment you have, and for your particular purpose. The exposure information provided by the manufacturers provides an excellent place to start from.

Film Latitude

All types of film have a considerable latitude of usable exposure range. The reversal films which are ordinarily used for 16 mm. work have less than negative film, because there is not the opportunity for correction during the processing. It is not at all difficult to stay within an acceptable range of exposure with either. Reversal films can still be analyzed even if they are as much as two full lens stops in either direction from the optimum level of exposure. However, such errors make the film analysis more difficult and should be avoided.

Film latitude is very important in so far as its ability to cover the tonal range of one scene. Light subjects require a very considerably less exposure than dark subjects; consequently, a film which is exposed properly for the darker portions of the scene will be overexposed for the lighter portions of the same scene. The lighter portions will be burned out. If the exposure is calculated for the light areas, the dark areas will be underexposed. They will not show detail. If there is not too wide a differential between the light and dark areas, a compromise exposure set somewhere in between will do a satisfactory job for both. In motion study it is generally better to expose for the key areas and forget about the remainder. Hands, arms, and objects handled are the usual key points. If it is possible to control the tones, avoid excessive contract. Satisfactory work can be done anywhere within the full tonal range, but not for both extremities at the same time.

Exposure Determination

Exposure can be determined by judgment, by use of an exposure chart or guide, by use of a light meter, and by exposure tests. The general practice of amateur photographers is to choose one of these and use it exclusively. There is considerable value to be gained from using all of them, although any one can be made to work satisfactorily alone.

Judgment: After a great deal of experience in estimating exposures and seeing the results of his estimates, one eventually becomes very accurate. Starting off from the beginning using only judgment will very likely be a costly experience. By using a guide or a light meter the experience can be just as good and cheaper.

Exposure Guide or Table: There is usually one of these tables in each package of film. More elaborate ones can be bought from camera

stores. If the directions are followed carefully, the results will be about the same as when using the light meter. However, these guides are more limited in application than the meter. For motion pictures, they usually cover four or five different outdoor light conditions and they will have a table for using a standard number of photofloods indoors. This does not cover all possible lighting situations, although it certainly does cover the usual ones.

Photoelectric Light Meter: There are other types of exposure meters, but the ones using the photoelectric cell are generally conceded to be the best. Experience in this laboratory has been limited to the Weston Master, the General Electric P R-1 and the General Electric D W-68. All three of these are excellent meters. Several others, some of which are cheaper than the ones named, would very likely serve well. Considering the volume of film which is used for motion study, particularly for accumulating data for predetermined motion time standards, the cost of a good light meter is certainly warranted.

There are three principal techniques for using a meter: namely, (1) measure reflected light from the subject, (2) measure reflected light from a substitute subject (ordinarily a gray card of standard tone) and, (3) measure incident light. Any one of these will give satisfactory results; however, the first one is not as consistent as the other two.

Reflected light is the light which forms the photographic image on the film emulsion. Its strength is determined by both the strength of the light and by the reflecting quality of the subject. The amount of light reflected from a particular object depends not only upon its color and texture, but also upon the angle from which it is viewed. This quality of reflected light makes it most difficult to determine when a good reading of the meter has been obtained. Several quite different readings are often obtained by making slight shifts in the position of the meter. There is difficulty in picking the right one.

A substitute subject is somewhat more reliable. An 18 percent gray card made by Eastman can be obtained, or a similar card can be obtained from other sources. The important point is to use the same tone and texture consistently. A standard card such as the one made by Eastman can be replaced if lost. In using the card, it is held so that the same light which falls on the actual subject falls on the card. The meter is held only a few inches from the card but invariably at the same distance. Care should be taken to see that there are no shadows cast on the card. Since the card is always the same, the reading will give a very good measure of the strength of the light falling upon the subject. This reading will not take into account the reflecting quality of the subject. If the subject is darker than normal (a lower than normal amount of light is reflected from it), the exposure must be increased. If the subject is lighter than normal, the exposure should be decreased.

The measurement of incident light is made by aiming the meter in the direction of the camera from the position of the subject. Only the light strength is measured. The exposure must be adjusted according to the lightness or darkness of the subject as described above for the substitute subject method.

The real value of a meter is to measure changes in light. It should not be thought that one can get the most desirable results simply by following the instructions which come with the meter. These instructions provide a good starting point. Adjustments should be made in the emulsion speed setting on the meter exposure calculator according to the results which are obtained. If the pictures seem to be overexposed for the intended purpose, set the emulsion speed index at a higher number. If the pictures are underexposed, set the index at a lower figure. Remember that an overexposed reversal film (positive image) is too light or thin. An overexposed negative film is too dense.

Exposure Testing: The quickest way to arrive at the most desirable exposure is by making an exposure test. Shoot a test film under the same conditions that will prevail for record shots if possible. Compute the exposure as nearly correct as possible by use of directions which accompany the meter, film or flood lamps. Then shoot test shots at this exposure and at a range of others as follows:

2 stops underexposure
1 1/2 stops underexposure
1 stop underexposure
1/2 stop underexposure
correct exposure (as nearly as can be determined)
1/2 stop overexposure
1 stop overexposure
1 1/2 stop overexposure
2 stops overexposure

If one finds that the exposure he had calculated is not as good as one of the others, he should pick the one that suits him best. Then he should reset the emulsion speed dial on his meter so that the same light value he read when making the test shots will give him the selected exposure.

From time to time use a tag end of a reel or magazine to run another test shot. If these are very short ends, try an underexposure one time and an overexposure the next. If a full stop overexposure always seems to be overexposed and a full stop underexposure always seems to be underexposed, then one should shift his test to one half stop over and one half stop under.

Written Exposure Records: It seems like a good idea to record exposure data and it is a good idea when one first starts shooting; but do not try to carry it on indefinitely. As soon as one gets his meter calibrated and exposures correct for his purposes, he

should drop this task. Fairly frequent exposure tests with tag ends of film will suffice to keep exposures correct. Motion study makes use of photography as a means - not an end. Continuing to keep exposure records is time consuming but not rewarding.

Film Editing and Editing Equipment

The job of editing consists of cutting out worthless lengths of film and of rearranging the scenes for greater convenience in analysis and eventual filing. There is a variety of reasons for scrapping certain scenes. There are photographic errors, but these are not frequently bad enough to spoil the film. The usual cause of film spoilage is the operator's failure to perform the work correctly. There are fumbles, methods changes, hesitations and equipment failures.

Film Viewer

There are several good makes of editing viewers on the market. However, if one is doing motion study he will need a time and motion film analysis projector. These projectors are excellent for editing. The film can be viewed with a full sized image. Little difficulty is encountered in finding the proper frame to cut. During the photographing, if a few frames are run through the camera (2 or 3 frames are sufficient) with the hand over the lens after each scene, it is easy to find the place to cut. This habit is easy to form and saves considerable time in editing. As the film is run through the projector, the useless scenes are cut and thrown away. Each good scene is allowed to run out on the floor or into a box. It is cut at the end and rewound into a film loop about an inch or so in diameter.

Film Rewinds

These devices consist of a spindle for holding a film spool, a gear box, and a handle. They cost only a few dollars. The rewind can be mounted on the table top directly or it can be mounted on a board so that it remains portable. A plastic film spool can be made into a convenient device for winding the film loops. The sides of the spool can be cut away with a pocket knife, leaving only the core. This core is placed on the rewind spindle and the film end inserted in the slit. Then, with the thumb of the left hand on one side of the core and the first finger on the other side, the film is guided onto the core while the right hand turns the crank. When the film has been completely wound onto the core, a very short length of sticking tape is used to fasten down the loose end. The plastic core can easily be pushed out of the film loop and the loop is ready to hang on the editing board.

The Editing Board

This can be made of a large sheet of the cheaper grade of plywood or similar material. Lines and columns of nails are placed on the board allowing a square of about 3 x 3 inches per nail. The film loops mentioned above are hung on these nails according to class and group. The columns may represent motion patterns; the lines, operators. Columns might also be used to represent operations; and lines, different firms.

Operator	Motion Pattern						
	1	2	3	4	5	6	7
A	/	/	/	/	/	/	/
B	/	/	/	/	/	/	/
C	/	/	/	/	/	/	/
D	/	/	/	/	/	/	/
E	/	/	/	/	/	/	/

↖↙ nails for film loops

Figure -- An editing board. The lines are not necessary on the actual board but the nails should be spaced 3 inches apart both vertically and horizontally.

Do not underestimate the need for an editing board. It organizes the job of editing and provides an excellent inventory of work completed. After the board has been filled, the loops are spliced into reels of the right combination. Usually all operators performing a particular motion pattern are spliced onto the same reel. Film analysis is much easier when reels are set up with all of one motion pattern on a single reel. The board cuts editing time in half. The editing board used in this project allowed space for 50 motion patterns for 15 different operators.

Film Splicer

There will be a large volume of splicing in preparing films for motion study analysis. Each reel will very likely represent a dozen or more splices. The Griswold splicer has done highly satisfactory work during this project. There are perhaps others which will do a good job. By all means get a sturdy one. This is not a good place to use poor equipment.

Filing Films

The important thing in film filing is to get started with an organized system at the outset. The system can usually be changed quite easily if a better one suggests itself and if there has been some order in previous filing.

A suggested means for filing is to number all reels consecutively and make up a 5" x 8" card for each reel to show what it contains. Do not try to use the same size reels for everything. Use the size necessary to hold the film but no larger. Attempting to stick to the same size reel all the way through causes some ridiculous situations.

If reels are not readily available, films can be kept wound on plastic cores and stored in cans away from excessive heat.

Cleaning and Storing Films

Eastman Kodak Company recommends a combination cleaning and lubricating of films.

> "Standard film-cleaning technique serves the dual purpose of cleaning and waxing in one operation. The film is rewound by slowly drawing it through a cotton pad which is moistened with a 0.03% solution of carnauba wax in carbon tetrachloride.* The pad can be folded over the film and held in the left hand while the right hand is used to operate the rewind. The operation should be carried out slowly so that the carbon tetrachloride adhering to the film will have an opportunity to evaporate before the film is wound. Work done with carbon tetrachloride should be performed in well-ventilated rooms.**"

If cleaning without lubricating is desired, carbon tetrachloride can be used without the carnauba wax. It is strongly recommended that one ventilate the room in which carbon tetrachloride is used.

In regard to storage, Eastman Kodak says,

> "For long life, processed films should be stored at the proper temperature and at the permissible relative humidity. The

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* Prepare this nearly saturated solution by placing a marble-sized lump of carnauba wax in one pint of carbon tetrachloride.

** Fume of carbon tetrachloride and Kodak film cleaner are toxic if inhaled. Use sparingly in a well-ventilated room.

ideal conditions are a temperature of between 40° and 50° F. and a relative humidity* between 40% and 50%. Black and white films can be stored at temperatures up to 70° F. and at relative humidities up to 60%."

An extremely dry condition will cause film to become brittle and, in this condition, it breaks easily on flexing. Too much humidity softens the emulsion making it highly susceptible to scratching.

If one anticipates difficulty in maintaining the desired humidity, it may be well to keep the film in sealed containers. The film should be pulled out loosely in a room which has been brought to the desired humidity level. It is left in this condition long enough for the moisture content to stabilize. Then it may be wound onto spools, put in the can, and sealed.

Clocks and Timers

There are several ways of obtaining measurements of elapsed time which can be used in conjunction with motion picture photography. The choice of one of these will probably be based on (1) economy, (2) accuracy, or (3) convenience.

Camera Drives

Spring Motor: If accuracy is not too critical, just the frame count when pictures were taken by a spring driven camera will suffice. The setting of 16 frames per second gives 960 frames per minute or, to all practical purposes, a .001 minute interval. Care should be taken not to take the frame counts of film exposed before the camera attained full speed and after the camera has wound down sufficiently far to slow down.

Non-Synchronous Motor: The electric non-synchronous motor camera-drive will be of about the same order of accuracy as a good governor-controlled spring driven motor. It has an advantage in that the full reel can be exposed without stopping. However, it is somewhat less portable since one must operate within extension cord distance of a power source or carry around a bulky set of batteries.

Synchronous Motor Drive: The synchronous type of motor gives accuracy of the same order as an electric clock. These drives are more expensive than the non-synchronous type but are worth it if a large volume of work is to be done, and particularly if extreme accuracy is needed.

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* Relative humidity is best measured with a wet- and dry-bulb thermometer.

Electric Clocks

A simple timer can be made for about $5.00. This can be inserted in the picture area and will give as accurate measurement of elapsed time as the more expensive motor drives and michrochronometers. Purchase a small clock-type synchronous electric motor which operates at 10 rpm. Mount this in a small box with the shaft projecting from the center of one of the sides of the box. Make sure that this side of the box is large enough for mounting a reasonably large clock face. Prepare a clock face divided into 100ths. Find a nut which fits over the motor shaft. Drill a hold in the edge of this nut (90° from the threaded hole in the nut) just large enough to accept a wire. Coat hanger wire is good for this purpose. Cut a length of wire long enough to serve as a clock hand. Solder the wire onto the nut. Place the clock face in position with the motor shaft projecting through the center. Place the nut with clock hand over the motor shaft and solder. This clock will measure in .001 of a minute.

The michrochronometer which was also used in the laboratory sells for about $100.00 and is essentially the same as the clock described above but has the convenience of an extra hand. The extra hand is of very little value in motion study since most of the cycles measured in motion study are of very short duration - seldom over a tenth of a minute.

The wink counter serves the same purpose but is constructed in a different manner.

Film Analysis Projection Equipment

The film analysis projector is an ordinary silent motion picture projector except that it will have a hand crank and may be provided with a special heat filter and a frame counter.

The hand crank gives the operator frame by frame control over the film advance or reverse. Some advance one frame per turn of the crank and others three or four frames per turn of the crank. It is much easier to stop the film at precisely the correct break point with the one frame per turn models. However, this advantage is offset by the larger number of times the crank must be turned for a reel of film. One model used an electric motor and a push button solenoid circuit. Experience with machines of this type proved unsatisfactory.

One of the best models (Bell and Howell Time Study Projector) is equipped with a special heat filter. This filter permits the use of 750 and even 1000 watt projection bulbs. The filter and the blower permit a single frame to be projected indefinitely without burning. Some of the cheaper models require the use of weaker

bulbs (200 watt or less). Where a weak projection bulb is going to be used, it is desirable to aim for thinner images. Thinner images are obtained by overexposure if regular reversal film is used; underexposure, if negative film is used.

Some machines have frame counters. The advantage of these counters is more apparent than real. The analyst must shift his eyes back and forth from the screen to the frame counter. The frame counter must be reset to zero after each reading, or computations must be made to obtain the elapsed time for the motion. Reading a clock in the picture area is no harder to do, is cheaper to set up and does not depend upon the camera motor for accuracy.

A particularly helpful adjunct to film analysis is a projection lens of short focal length. The one-inch lens is about the optimum. Shorter focal length lenses are available, but there is some loss of image quality at the extremes and also the extremely large image requires an excessively strong projection bulb. The larger image obtained from a one-inch projection lens is easier on the eyes of the analyst and motion is much easier to detect. At a given distance, the one-inch lens projects an image four times the area of that projected by the two-inch lens.

A larger image can be obtained with the regular two-inch lens by increasing the lens to screen distance, but the analyst must sit at the projector. Where the shorter focal length lens is used, it is important to use a reasonably fine grain film since the increased image magnification also means increased grain magnification. The image from large grain film breaks down to a poor quality level.

There is no need to buy a commercial type of beaded screen. A 30" x 40" piece of white drawing paper or cardboard, preferably with a matte surface is ideal. Beaded screens increase the image brilliance, but that is not needed for the short distances projected for film analysis.

Sometimes it is desirable to project in a fairly well lighted room. This can be done very well by projecting into a shadow box. This device can be made by fastening a sheet of white paper or cardboard to the inside surface of the bottom of a cardboard box. The inside surfaces of the sides of the box should be painted black for best results.

Occasionally a film will be taken in which there is a large highlight area. This will be hard on the eyes if steps are not taken for correction. There are several ways of alleviating this difficulty. A colored filter can be slipped over the projection lens. A yellow filter seems to solve the problem in most cases. One can also shift to a weaker projection bulb. This solution will not work if key areas of the image are in shadow. A colored screen might be used. A blue, green, or gray screen will darken the highlights sufficiently to ease eye strain. Sometimes a black screen will solve the problem.

If the highlights are in an unimportant area, move the screen so that this part of the image does not hit the screen. And finally, use more light in the projection room. It is not the highlights alone that hurt the eyes. It is the constant shifting from light to darkness and back again. The pupils of the eyes are continually adjusting to either one extreme or the other. This causes eye strain in a very short time.

Variations from Orthodox Motion Study Film Technique

Ordinary motion study will cover the motion picture speeds of 16 frames per second (normal), 32 frames per second (intermediate), and 64 frames per second (slow motion). Decimal time units may be used also. In that case, 1,000 frames per minute corresponds very closely to the normal 16 frames per second, 2,000 frames per minute compares closely with 32 frames per second, and 4,000 frames per minute is practically the same as 64 frames per second or slow motion. There are camera speeds below this and above this which are quite useful for specific purposes.

Memomotion

Pictures taken with a motion picture camera driven by a synchronous motor at the rate of one frame per second or 100 frames per minute have been designated as "memomotion." This rate is very economical in the use of film. A one hundred foot spool will last for one hour and six minutes at one frame per second. However, the intervals are too great to be of much use in recording motions. Time measurement is extremely accurate, but this is not the difficult part of time study. One can obtain accurate time measurement with the stop watch when elements are long enough to be measured in seconds and hundredths of a minute. Furthermore, the stop watch record is completed during the timing; whereas, memomotion film must be analyzed. For ordinary time study purposes, one should consider carefully whether the extra accuracy of time measurement warrants the extra cost.

For recording the interrelated activity of a crew (men and machines) the memomotion technique is extremely useful. Gang charts or man machine charts can be constructed quite easily from a memomotion record. Each person and each machine can be analyzed from the film individually. It is often impossible for a single observer to obtain such data with a stop watch, with acceptable accuracy.

Memomotion is also useful in obtaining a record of travel between work stations where more than one person is working. This type of record provides the data for making a Link Analysis.

If data is to be collected from only one person, it is doubtful that memomotion is the proper technique. For the two purposes listed above it can be a highly valuable tool.

Slower Than Normal Motion Picture Speeds

Some work can be measured adequately by using 4, 6, 8, or 10 frames per second. Where this is a standard condition, there is no particular value in using a faster camera speed. Walking short distances, stacking heavy objects, and using materials handling equipment can usually be measured satisfactorily at these speeds. There are several advantages in using the slower speeds where they suffice. A slower film can be used. Much less film is used. Cameras need not be loaded so often while photographing. And film analysis takes less time. After work has been completed, it will reduce confusion to convert all data to a standard time measurement unit such as a thousandth of a minute or tenth of a second. Sticking to one camera speed can be a very expensive practice.

Ultra High Speed Cameras

The use of ultra high speed motion picture cameras can generally be considered as beyond the needs of motion study. Their specific use is in the study of the motions of a mechanical device which operates at speeds too high to be recorded even at slow motion with the ordinary movie camera. These cameras are quite useful in locating the cause of mechanical malfunctions.

Camera with Intervalometer

This combination differs from memomotion only in the interval between successive shots. Intervals up to one minute and longer are obtainable. This type of equipment can be used in conjunction with the movie camera as well as with a still camera (usually 35 mm. still camera). A specific use of such equipment is the measurement of loading time at a loading platform. It is useful also in determining the time used in the various steps of a job of considerable length. The film record is rather inexpensive when compared to the time of an observer.

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CHAPTER XIV

INSTRUCTION METHODS

Work simplification research too often ends with the selection of a better method. If the work stops there, the research is indeed sterile. No matter how good the selected method, it produces no increase in productivity until it is put into use. Estimates by practicing methods engineers indicate that less than 20 percent of their time is spent in finding a better method. The remainder of their time is spent in selling it to management, selling it to workers and teaching it. The selling phase is a necessary preparation for teaching.

Selling to Management

Management has a natural resistance to change. Some of its reasons for resistance are good, some are poor. This resistance must be overcome before further progress is made. There are several quite different reasons for resistance to change and correspondingly several ways of overcoming them.

Lack of Evidence that the New Method is Better

In spite of the great number of business failures, the people who are running businesses at any one time are mostly successful in some degree. Consequently, from their point of view, the methods engineer is asking them to substitute an unknown procedure for one of proved value. It is not unreasonable for them to ask for proof that the new method is really better.

Probably the best proof that a new method is really better is obtained in the form of comparative cost studies and comparative time studies. Such studies invariably show that even the best plant is not best in every operation. Once the manager has been shown that improvements are possible, he is more likely to listen to the specific plan.

Introduction of New Method Costs too Much

If this is really true, the methods engineer is wrong in trying to sell it. The comparative cost study and comparative time study provide basic data. From this data, comparative budgets can be set up showing the cost with the present method and the cost with the proposed method. Output volume and other pertinent data are incorporated into these budgets.

Paradoxically, the firm which is marginal or very nearly so, may be the hardest to convince. The reason for this is that a small mistake in judgment will be sufficient to put them out of business. They have no reserve for experimentation. More successful firms have less reason to change, but experience has shown them to be the most receptive to improved methods.

Failure to Understand the Idea

There is a human tendency to discredit that which is not understood. If a methods improvement is written or spoken in a complex or confused manner or in highly technical terms, there is little chance that the prospective user will bother to dig out the real meaning. It is much easier to label it "bunk".

Describing a work method in a clear and easily understood manner is a most difficult task. Every means should be exhausted to make the description lucid. Technical language had better be reserved for discussions with fellow workers.

Inertia

There is a natural human resistance to change based on the fact that it is more comfortable to follow an old habit than to change it. The greater the change the more energetically it will be resisted. That which might be accomplished bit by bit over a period of time might well be rejected completely if presented too abruptly. Alan Mogensen compares human nature in this characteristic to a gyroscope which can be easily moved a little way but strongly resists any major movement. Sometimes the methods engineer will do better to instigate a successful compromise method rather than have the ideal method rejected completely because it is too drastic a change. Older people give more trouble in this respect simply because their habits are more deep seated and consequently harder to break. However, complacency with the status quo is not unheard of among young people.

Lack of Participation

Often management will take no interest in a new method simply because they had nothing to do with originating it. This lack of interest can easily blossom into hostility if the methods engineer has been tactless in introducing the method. There is an implied criticism of management when a new method is introduced regardless of how tactful the methods engineer may be. This is a touchy situation. The most practical answer to this problem is to bring management in on the methods improvement investigation.

If they participate in working out the method, they feel much more favorable toward the change. Even this solution requires a high

order of tact on the part of the methods engineer. He can nullify any possible gains by projecting his own ego too noticeably into the scene.

One should not ignore the foreman and intermediate levels of management. It frequently happens that the fate of a new method lies in their hands. It is not reasonable to expect them to exhibit enthusiasm when they have been ignored.

Fear of Loss of Prestige

Often the introduction of a new method means cutting down the crew or other responsibilities of a boss. This is an important point because it means that he loses prestige. Any move which lowers a man's prestige is certain to be looked upon with disfavor.

If methods improvement cuts down on a supervisor's responsibility in his old job, it is frequently possible to broaden his job in other directions. It is also beneficial to emphasize increased efficiency in his department.

Disruption of Schedule

Smooth scheduling is too often mistaken for efficiency. A boss who keeps his crew occupied at all times can easily convince himself that he has a really high level of efficiency. Methods improvements can and do mutilate such well planned schedules.

After methods improvements have been adopted, the outward appearance of the work operation often is considerably poor. Still the productivity may have increased considerably. Readjustment can eventually be made which will improve the appearance of the operation. In the final analysis one frequently must choose between looking efficient and being efficient.

Selling to Workers

The reasons why management resists change do not differ greatly from reasons of workers except in degree of emphasis. There are some points which are of particular importance to workers.

Lack of Motivation and Other Negative Aspects

For the most part, management simply introduces the change. The individual workers are the ones who must break old work habits and learn new ones. Frequently there is no increase in pay. Yet supervisors are amazed at the lack of enthusiasm for a better method on the part of the worker. There should be some appeal based on the

worker's interests: better pay, shorter hours, making the job easier, greater safety, more prestige or similar incentives. Management is indeed blind when it operates as though self interest applies only to the management level.

From the viewpoint of the worker, the situation brought about by a methods change is even worse than simply a lack in motivation. There are many negative aspects which are quite tangible in nature. First, there is the uncomfortable task of breaking old habits and learning new ones. Accompanying this procedure there is likely to be some fear that the new ones will not be learned adequately and the job will be lost. Frequently the new method reduces the job content from a skilled to non-skilled classification with accompanying loss in prestige. After a methods improvement fewer men are needed. Some may be fired and the remainder put under higher competitive pressure. Old familiar work crews are often broken up and the worker is shifted to a new and strange environment. The tactless attitude of management in introducing the method is often sufficient alone to insure its failure. No forewarning is given of the change and, in many cases, drastic changes are made in crews, layout, and equipment. Workers do not know what is going on. Even the lower levels of management are sometimes in the dark. Add to this a superior attitude on the part of those effecting the change, and criticism of the worker's old method. There is a substantial basis for a lasting antagonism on the part of the workers toward the improved method. No matter how good it might be, the new method is likely to fail.

Remedial Measures

There are several remedial measures for gaining greater favor from workers toward new methods. One of the most important is an incentive pay system. If the worker is payed in proportion to output, he will be more interested in improved methods. The effectiveness of this measure will not last long, however, if management sets a tighter rate every time a new method is introduced, making it clear to workers that they intend to reap all of the benefits of better methods. Neither is entitled to all. Management should not use the change of method just as an excuse to tighten the rates.

Showing a sincere interest in the worker can be beneficial in gaining cooperation. This may not be an easy thing to generate unless there really is a sincere interest. A patronizing manner can do more harm than good. Hypocrisy will most likely be detected quite readily. But even where the interest in workers is sincere, there are pitfalls. Too much familiarity may destroy discipline. The exponents of the "one big happy family" philosophy of management-worker relationship usually fail to warn of this pitfall. Examples are numerous, especially among hired managers. It is easy for a boss to gain a kind of favor with his crew by being very easy on them. Showing a real and sincere interest in workers does not mean that a day's work is not expected.

It means that the boss is interested in the health, comfort, safety, progress, and welfare of his men. One effective way of showing interest in workers is to know how much each man does--and let him know it. The man who is doing well appreciates this interest. The one who is not doing well may start doing better.

Too often the worker is not informed as to why he is doing a particular task. He can have but a shallow interest, if any at all, unless he is made to see the value of his work. Any person likes to feel that his efforts are constructive. Better communications to the entire working force are often needed.

Wherever possible, the work should be set up so that it is easy for the worker to keep account of how much he is doing. Competition with fellow workers and with one's own record is stimulating. When one knows how much he has done, there is a greater sense of accomplishment and less monotony.

Workers should be made to feel as secure as the situation permits. The old fashioned way was to threaten to fire a man if anything went wrong. The modern trend is more reasonable. It is becoming increasingly apparent that no one must lose his job as a result of introducing an improved method. If men are laid off, management has virtually insured that methods introduced at a later date will fail. Even though some men must be carried on the payroll for a time without being fully occupied, it is better to keep them. Normal turnover and plant expansion can be expected to take care of the excess number in time.

The value of introducing safety devices and making changes which affect the comfort of the worker is hard to assess. Such changes do not affect productivity directly. It is unrealistic for management to expect any great show of gratitude. Yet such changes can be quite effective in a more subtle way. Antagonism toward management may be considerably less and the result may mean greater cooperation on the part of the workers. Increased productivity is very likely to result, but may come in such a form that it would be impossible to trace it to the cause.

When investigations are being made with the objective of finding better methods, one will do well to enlist the aid of the workers. In the first place, they are a likely source for some excellent ideas. But, even more important, they will feel that they had a part in it. They were consulted as fellow human beings. They have had a longer period to get accustomed to the idea of any proposed changes. This will often result in a vigorous campaign to make the new method work. Under these circumstances the new method will most certainly work if it is any good at all.

Some discussion of this all-too-general human characteristic of resistance to change should prove beneficial to all concerned. The methods engineer must be cautious lest he reject an excellent idea

simply because someone else had it. Resistance to change seems to be reduced in those who are most aware of it and the reasons for it. At least, one is forewarned against permitting his reactions of resistance to get the upper hand.

Teaching Work Methods

There are several types of methods problems; namely, layout, materials handling, communication, crew organization and balance, selection of machinery or equipment, and motion study. For each of these there are certain methods engineering techniques which are particularly applicable in finding a solution. Having arrived at a solution to the methods problem, the next phase is to teach it to those who can use it in actual production.

There are several teaching techniques; namely, reading assignment, lecture, discussion or conference, demonstration, and coaching in actual or simulated practice. There are also numerous devices which aid instruction; namely, visual aids, audio aids, audio-visual aids, and synthetic training equipment. These teaching techniques and aids will be examined in their specific application to each of the different types of method problem.

Layout

Presenting an improved layout is a graphic problem. Visualization is of key importance. Prose descriptions alone, whether in written or lecture form, are likely to be quite ineffective. Sketches or floor plans drawn to scale and showing the appropriate arrangement of equipment will be more effective than words. The flow diagram is quite useful for showing just how the layout is to be used. Sometimes one may be justified in using the more elaborate and more expensive small scale or make-up models. A pilot set-up using actual equipment may be the best solution when it is not too expensive to obtain.

The sand box is useful for representing outdoor layouts. It is especially good for showing arrangements on rough terrain.

In general, sketches and diagrams are better than still pictures and slides because there is no extraneous material shown in them. However, still pictures or slides may be perfectly adequate in some instances. Where pictures are used, effort should be made to exclude clutter.

Materials Handling

Still pictures are excellent for illustrating the equipment. These should be accompanied by thorough specifications covering purchase price, speed, capacity, fuel cost, probable length of useful life, and

all pertinent advantages and limitations in the use of the particular piece of equipment. Too often the materials handling instructions are prepared by a manufacturer. Such information is seldom adequate. Its primary purpose is to promote sales and stating the important limitations of equipment seldom serves that purpose.

Except for case studies, one type of materials handling equipment cannot be the only answer. Expensive fork lifts cannot be justified where volume of handling is low. In presenting the materials handling instructions, the importance of volume and timeliness should be thoroughly considered. Usually the answer will indicate some inexpensive device like the two wheeled hand truck for low volume, another type for medium volume and still another for high volume. One must recognize in preparing instructions that needs vary.

Diagrams of the same type as the flow diagram can be used effectively to show the pattern of travel in using materials handling equipment.

Communications

The various types of communications equipment can be illustrated by still photographs and should have equipment specifications accompanying the pictures. Here again a diagram can be quite helpful in showing the arrangement of unit installation. There should be very little difficulty in putting this type of information across to prospective users.

Crew Organization and Balance

If the problem is one of timing and coordination among the members of a crew or between men and machines, the multiactivity charts are most useful. These are the gang chart and man-machine chart. Although these charts are generally thought of as devices for solving methods problems, they are also useful in presenting the results. A verbal description of the activity should be given along with the chart to bring out the key points. There should be some technique for showing which elements must necessarily be coordinated. A motion picture with appropriate voice instructions would be even better than charts.

Balance is a matter of assigning the proper number of workers and/or machines to an operation. The capacity of the crew should be as close to the volume expected of it as can be determined. There should be no serious bottlenecks; each part of the crew should be working at near capacity. An example such as Figure 1 may be helpful in illustrating this problem. The problem of assigning just enough and not too many workers is graphically represented. The total capacity represented by packers is 950 in this example which sets the

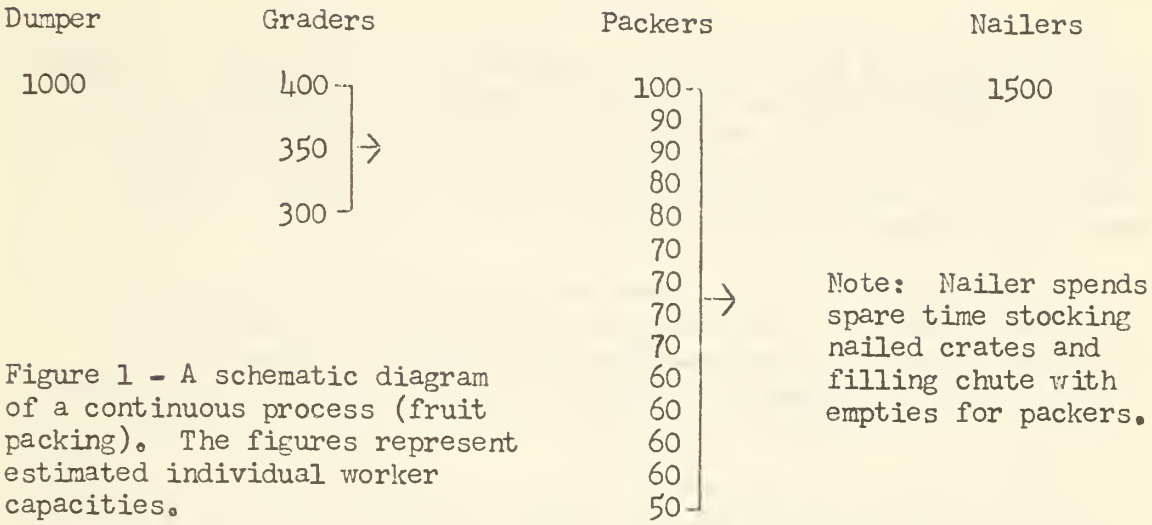

Figure 1 - A schematic diagram of a continuous process (fruit packing). The figures represent estimated individual worker capacities.

output for the entire crew. It is not realistic to expect exact balance. In this instance, one more packer would improve the balance.

Crew organization can also be considered in terms of the administrative set-up. This information is usually presented in the form of an organizational chart. This type of presentation is useful in establishing lines of responsibility. It should be accompanied by verbal instructions concerning duties and responsibilities.

There is, too, the problem of the geographical distribution of the crew. The labor for a certain operation may be pooled; for another, decentralized. Whatever the solution, there should be sufficient information given to indicate the advantages and limitations of the choice. A diagram of the plant and the flow of work or workers in the particular operation may be helpful.

Selection of Machinery and Equipment

The most useful tool for presenting this type of information is the comparative budget. Where there is a variety of machines available, there will usually be a range in output capacities of these machines. The answer will seldom show that one specific machine ie unconditionally the best choice. Ordinarily, examination of comparative budgets will show that when output volume decreases below a certain point, some less elaborate and less expensive machine will be more economical.

Certain maintenance and operating instructions may be given for the machine in written form and with still pictures or line drawings used to illustrate. Steps in a procedure or check lists are usually more effective in written form than any other way of presenting them. If one wishes to show a motion pattern which may be used in operating the machine, the recommendations of the following section on motion study apply.

Motion Study

The results of motion study are logically the selection of a most effective motion pattern. This type of material is referred to as physical skills or motor skills. The teaching of such material is generally called training. It involves more than just an understanding. The trainee is expected to attain some minimum level of actual performance ability.

Teaching skills presents some problems which are quite different than is encountered in the foregoing types of methods improvements. The introduction of motion complicates the problem beyond the scope of words and still pictures. A motion which is quite easy to perform can be extremely difficult to describe.

Verbal presentation, either written or oral, can be used effectively to introduce the subject, to state objectives, to set up training schedules, to answer questions, to list materials which will be used and for various other auxiliary purposes in teaching skills. Still pictures can be employed effectively also in these phases. However, either live instructor demonstration or motion picture demonstration must be used for the bulk of the teaching if it is to be effective. Visual perception is far more effective than audio in dealing with motion.

Just observing the demonstration, either live instructor or film, might suffice in some instances if the motion pattern is very simple or if the level of skill sought is rather low. Ordinarily, practice sessions should follow the demonstration. It is during these practice periods that the instructor performs his most important duty. He instructs in key points of performance. He watches for errors and corrects them. He emphasizes good performance. He tries to guide the practice so that the correct method is practiced rather than some inferior deviation from it. The old saying that "practice makes perfect" is not exactly untrue but needs some qualification. One can become better and better at performing an ineffective motion pattern. It is of great importance to avoid this; because, once the habit is formed it is hard to break. A person habituated to a poor motion pattern is really in a worse situation than one who is entirely unfamiliar with the work.

A sequence of still pictures is sometimes used to depict motion. The principal reason for using this technique is economy of dissemination. If the motion pattern is simple, or if the sequence of steps is more important than the exact method of performing them, this form of presentation may be adequate. In any case, it can be quite useful for introductory material concerning the new method. The general pattern of motions can be seen quite clearly in a sequence. The details of motion performance can then be shown by demonstration. The sequence is also quite useful for reviewing a method which has been learned but which has not been practiced recently.

Experience gained during this project has indicated quite forcefully that long-winded explanations of a method accomplish but little. A quick demonstration with the worker observing over the shoulder or to one side and slightly to the rear of the demonstrator was used to start off the instruction. A few words were used to point up one or two key points during the demonstration. These should be quite limited. If there are several points to be covered eventually, one should bring them in later. As soon as the demonstration was completed, the worker was asked to begin practice. Corrections were made of the method while the worker was practicing.

The angle from which the worker observes the demonstration is quite important. This is called the subjective angle. The worker's body and the demonstrator's body are oriented in the same direction. In this position, the worker most readily identifies his own body member with that of the demonstrator. A 180° point of view can be most confusing to the worker because he must reverse everything he sees in order to reproduce the performance. When the worker is watching from the zero or subjective angle, he experiences nerve impulses in his own body member which corresponds to the body member being used by the demonstrator. This level of identification of the worker with the demonstrator actually has been known to substitute adequately for some part of actual practice. In other words, the actual practice period could be shortened. In order to impress upon the mind the importance of using the subjective angle, one should try it out. He might show one person how to tie a knot from the subjective angle and another person from the 180° angle. The efficacy of the subjective or zero angle will be quite apparent.

Some Comparisons of Alternative Teaching Techniques and Teaching Aids

In a good many instances the person who is responsible for instruction must choose between two alternative instruction techniques or between two alternative teaching aids. As might be guessed, the range in effectiveness of any one technique or teaching aid is so broad as to produce considerable overlapping. However, some examination of specific comparisons may prove helpful.

Written Instructions Versus Oral Instructions

There is not a definite general answer to this problem. The oral instruction or lecture arouses greater interest but may lose somewhat in accuracy. The amount of interest achieved by a lecturer is governed a great deal by the instructor. Note taking during a lecture increases accuracy in obtaining details, but it detracts from learning directly from the lecture. In the dissemination of methods improvement information, it appears that the better solution is to prepare written instructions. Then if personal instruction time is available, it can be used to demonstrate parts of the method which involve motion and

to answer questions. Generally speaking, the instructor's time can be put to better use than delivering a lecture. There will remain certain auxiliary duties of the instructor which must ordinarily be accomplished orally; namely, introducing the subject, explaining what the written material is for, and stating the objectives of the class.

Live Instruction Demonstration Versus Motion Picture Film

Experiments have shown that motion pictures can substitute quite satisfactorily for live instructor demonstrations! This does not mean that the instructor is displaced by film. It means that he can spend more time performing his most important function; i.e., correcting errors as he observes them during practice and emphasizing good performance.

There are two real advantages in the use of motion pictures for demonstration. First, there is no great difficulty in presenting the demonstration so that the whole class can see from the best angle of view. Remember the vital importance of using the subjective viewpoint or zero angle of observation. The pupil must see the demonstrator's body oriented in the same direction as his own so that he can identify the members of his own body with the members of the instructor's body which are being used in the demonstration. A live instructor cannot achieve this except with a very small class. In demonstrating finger motions, it may be difficult for him to show more than one pupil at a time by live demonstration. The motion picture does not have this limitation.

Secondly, live instructors available for the task may be less than expert in performing the demonstration. Errors in performance and any show of a lack of top skill will detract from the interest of the class. Nevertheless, expert performers are not always available; and, even if they were, they frequently make very poor instructors. By using a motion picture demonstration, a good instructor can greatly broaden the scope of his instruction. Even the work of poorer instructors is enhanced greatly by a good film.

In view of the fact that motion pictures are proved to be truly effective in the task of demonstrating physical skills, it is believed that some aspects of motion pictures should be examined to see what is really needed in a training film. The qualities which make a good film for entertainment purposes are not necessarily pertinent to the objectives of training.

Color Versus Black and White:-- Almost invariably people prefer color and their interest is strengthened by using color. Interest is an important factor in learning. Still, color is not nearly as important an interest factor as subject matter. In view of the fact that color greatly increases the cost of producing a training film and the increase in effectiveness is almost negligible, the use of color is not

generally warranted. There are perhaps some rare cases where color provides a key learning cue and would be justified. It is probably a very rare coincidence when both color and motion are important in the same task. Ordinarily when color is important, the less costly still slides can be used.

Stereo Versus Two Dimensional Films:-- Tests conducted by the Navy Department showed no increase in learning when stereo motion pictures were used. Just as in the case of color, there are perhaps some instances where binocular vision would be of key importance in learning. There are several cues to depth in ordinary motion pictures. Unless binocular vision specifically is needed, stereo motion pictures do not seem to be justified. There may not be so much added cost in producing them, but there are serious limitations encountered in showing them.

Professional Trick Effects Versus Straight Photography:-- There are several tricks used by professional motion picture producers which are designed to make the picture smooth. These include fades and dissolves, wipes, extreme close ups, attention-gaining devices such as arrows or dancing symbols, and sound effects. The evidence shows clearly that these do not add to the instructional value of the film, and may even distract the learner. A straightforward motion picture of the subject was most effective. Sound added to the effectiveness of the film but mostly when a moderate amount of verbalization was used to forewarn the audience of a key bit of action. Explanations which followed the action interfered with the learner's attention to the film. Since these extra tricks are quite costly and since they do not contribute to learning, they should not be used.

Introductions and summaries were found to be in the same category as trick effects. They added nothing to the effectiveness of the film.

Single Showing Versus Repetitive Showing of Motion Picture:-- The results of experiments conducted by the Navy Department indicate that a second showing adds greatly to learning from a motion picture. Third and fourth showings and higher repetitions did not add a significant amount to learning in their tests. However, the nature of the material must be taken into consideration in determining how many repetitions will be of positive value. For a complex skill, several showings may be of value. In one experiment, a film loop was prepared which showed repetitively a cycle of the task. This procedure proved quite effective, especially when the film was alternated with periods of actual practice during which the instructor coached the class in performance trials.

Silent Versus Sound Films:-- In deciding whether sound will add significantly to learning, one must consider the teaching problem. If the task is rather simple, one might gain considerably in effectiveness by using the voice to forewarn of a key point in the action. However, if the motions are complex, it may be better for the instructor to provide the voice.

The learner may need to watch the film many times. After the first showing, the voice can add little but irritation and distraction. A silent film would seem to be the best choice.

There are cases where sound provides a cue to action and, in those cases, sound is valuable. Ordinarily in teaching motions the primary learning will come from the visual demonstration of those motions. It is easy to overrate the value of sound when teaching motions.

Still Versus Motion Pictures:-- Motion pictures are not inherently better than still pictures for teaching, except for teaching motions or about motions. If motion is not a characteristic of that which is to be taught, a still picture of slide probably will better serve the purposes. A slide can be left in position as long as the instructor wishes. There may be several features he wishes to point out. If one tries to use a motion picture for such a subject, he must determine when he makes the scene how long he will want to show it. At regular silent motion picture projection speed, 10 feet will last for 25 seconds. Where motion is not the vital point, a motion picture is not as well suited as a still.

Transferable Versus Non-Transferable Skills

When one sets about learning a new skill, he usually brings to the new learning task experiences which will make the task of learning this new skill easier. He has learned some skill in the past which was similar to the new one. If he has learned to drive an automobile, he will probably experience relatively little difficulty in learning to drive a truck. There will be a positive transfer of skill from automobile driving to truck driving.

For every motion there is a stimulus and a response. Usually the stimulus is the preceding motion. A habit pattern has been formed in which this motion always follows that. Sometimes the stimulus is different. It may be something seen or heard. At any rate, there is a stimulus. The act or motion is the response.

If a person goes from one learning task to another in which the stimulus-response relation is the same, positive transfer will occur. The greater the similarity of both the stimulus and the response, the greater will be the transfer. Usually the transfer will be even greater if the first task was overlearned.

If there is a reversal of the stimulus-response relation, the more similarity there is between the stimulus and responses of the first task and the second, the greater will be the negative transfer. This principle explains why it is frequently cheaper to train a green, completely inexperienced person than to retrain an old timer whose method must be altered.

Failure to understand the nature of transfer often causes enormous waste during the training period. Somewhere the idea has developed that training must be done on the actual operation. But many of the basic skills can be learned cheaper and more effectively at synthetic training set-ups. One does not need to go onto a busy warehouse floor to learn the fundamentals of operating a fork lift truck. Nor should he take a perfect greenhorn to busy downtown traffic to teach him how to shift gears in a delivery truck. The fetish for training under real work conditions can be very costly.

There are many agricultural marketing skills which could be taught at agricultural colleges by using synthetic commodities rather than the real thing. Real agricultural commodities are often perishable, making them most inconvenient to keep in practice set-ups. If motor skills are to be taught, there must be adequate facilities for demonstration and practice. Bulletins and lectures alone will not accomplish the task.

Coaching Versus No Coaching

Regardless of whether the demonstration is by live instructor or by film, its effectiveness is greatly increased when followed by a practice period and coaching. Coaching consists of instruction in key points, correcting errors and emphasizing good performance. In the early stages of practice, it is not possible for the individual to see effectively his own mistakes. Thus an error will frequently become a fixed habit.

When a person works at a highly repetitive task for some time, the motions gradually become automatic. At first, he has to think about each move. A little later he only has to think when deviations in the work pattern occur. But even the deviations are usually repetitive in a lower degree. Finally the whole task can be done without conscious thought. At this stage, if he has developed a bad work habit, it can be corrected quickly. But the correction lasts only as long as the worker is thinking about it. If the instructor leaves him for a few minutes and then comes back, he will ordinarily catch him at his old bad habit again. The back sliding is not a deliberate rebellion. Anyone who has tried to correct an old bad habit in some form of sports will recognize how great the difficulty really is.

A variation from trained instructor coaching is the coach-and-pupil technique. The instructor divides the class into pairs. Only one person in each pair practices at a time. The other one acts as his coach. Even though the coach in this set-up is as much of a novice as the pupil, the technique is quite effective. It is easier to see someone else's error than it is your own. Furthermore, the "coach" learns from his coaching duties. This technique is particularly well suited to handling large classes. In the first place, it divides in half the number actually practicing for any one time.

Furthermore, the novice coaches can correct the most glaring errors, leaving the trained instructor more time to handle the difficult cases. The technique is an economical expedient if trained instructors are scarce.

Concluding Comment

Instruction is the final step in activating improved work methods. Without it the methods research will be of very little practical benefit. The results of most agricultural research can be desseminated adequately by bulletins and lectures. A large part of method research can be handled in the same fashion. But, recognition must be made of the fact that teaching motor skills or motions is a different problem.

Teaching techniques and aids which are appropriate to this problem should be adopted. These techniques are well known in the armed services and in athletic circles. It is not necessary to originate new ones for agriculture. A little adjustment is perhaps needed in fitting them to specific agricultural uses. The important point is to realize the need for these teaching techriques and teaching aids in implementing work efficiency studies toward their most useful destination. The great need is to start using them.

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Daylight Projection of Film Loops As the Teaching Medium in Perceptual-Motor Skill Training.

Commentary Variations: Level of Verbalization, Personal Reference, and Phase Relations in Instructional Films on Perceptual Motor Tasks.

Effect of Learner Representation in Film-Mediated Perceptual Motor Learning.

Relative Effectiveness of Color and Black and White in Instructional Films.

Effect of Repetitive Film Showings on Learning.

The Value of Note-Taking During Film Learning.

Effects of a Stereoscopic Sound Motion Picture On the Learning of a Perceptual Motor Task.

The Effect of Attention Gaining Devices on Film Mediated Learning.

The Relationship of Optical Effects and Film Literacy to Learning from Instructional Films.

CHAPTER XV

RECOMMENDATIONS

In the course of completing this project, several mistakes have been made and time lost because there was no guide or precedent for methodology. Industrial firms which have engaged in the task of collecting predetermined motion time standards have not seen fit to publish their experiences in collecting data. The following observations will not answer all questions in methodology but should provide a means for avoiding some of the more costly errors.

Work Performance Time Data

If work performance time data is to be taken from the realm of guess work, masses of data must be collected under the most carefully prescribed working conditions. This time data must be accurately measured. That is not a difficult task if the work is broken down into parts which are truly separable.

Motion Description Versus Time Measurement

Work done during this project has indicated that motion descriptions must be thorough and accurate if meaningful data is to be obtained. Thoroughness does not refer to the length of the description so much as to the recognition of all significant factors which affect the motion's performance time. If the motion is simple, there will be few factors affecting its performance time; consequently, its description can be quite brief. If the motion is complex, there will be more factors affecting it. If the significant factors affecting this complex motion are recognized, however, its description need not be unduly long. One of the major accomplishments of this project has been to measure the effect of the various factors on particular motions; or, as it turned out in some instances, the lack of effect.

In the beginning of work on this project, method descriptions were made in terms of basic motions. There has been no indication that any change is needed in this area. It will be noted that the method descriptions in Chapters VII, VIII, and IX are all made in terms of basis motions even though the time values are presented in the combined form designated as get and place. The reach is described and the grasp is described, but the time value is given for the reach and grasp combined. This combination was called get.

It was apparent to the members of this project as it must be to anyone who has engaged in motion study that film analysis to obtain time values for individual basic motions is a very time-consuming operation. Some thought was given to the possibilities of obtaining time values for combinations of motions early in the project, but a complete reliance

on this procedure was not deemed wise. However, when the Contract Amendment was submitted it included a provision permitting the testing of data in the combined form referred to therein as get and place data. This procedure referred to the time values only. It did not change the motion description. The results obtained from time data in the combined form exceeded expectations. The effect of individual factors could still be isolated by using the technique of matched pairs analysis. It is believed that time data for complete cycles might even be used in conjunction with matched pair analysis to provide very thorough analysis of the factors affecting work performance. If cycle time data were used, the method description should still follow the same pattern as for the complete motion breakdown. Each individual motion which makes up the cycle should be described thoroughly in terms of the factors which affect its performance time.

Get and Place Versus Complete Motion Breakdown

The contract provisions for this project specified that the complete motion breakdown would be made. As the work progressed, it became apparent that certain motions are not separable except in an arbitrary sense. When motions are measured on the basis of arbitrary rather than a natural breakpoints or separations, the data cannot be completely accurate. The time value assigned to a reach may contain some of the grasp which follows, or vice versa. This characteristic limits the usefulness of such data. What appears to be a significant variation frequently is only a deviation in film analysis.

It was noted that reach and grasp combined made a comparatively independent segment of work, and that move and position-release did also. If there were any orienting, such as turning the labels of canned goods when stocking grocery shelves, it would be lumped together with the move and position-release. The reach and grasp combination is referred to as get. The move and position-release is referred to as place.

At first the get and place breakdown appeared to be too gross to be adequately sensitive to variations in the factors which affect work performance time. An examination of data thus compiled dislodged this opinion. There are comparatively clear cut breakpoints at the end of grasp and at the end of release. These breakpoints mark the beginning of a change of direction of movement in most cases. The greater accuracy of measurement made possible by these clear cut breakpoints provides an even better basis for evaluating the effect of factors.

There was some reason to continue the complete motion breakdown in order to provide a measure of skill. It was discovered later that the fast performance time average divided by the normal performance time average was at least as good an indicator of skill content as the correlation. Furthermore, it is easier to understand and easier and cheaper to compute. It is difficult to evaluate the accuracy of these

measures, but the ratio of fast to normal coincides more with personal judgment of skill factors than the correlation. It seems most certain that it measures skill somewhat better.

The get-place data serves the purposes somewhat better than the complete motion breakdown and it is substantially cheaper to obtain. If the film is photographed at the same speed, the film analysis requires only half as much time. But since the gets and places are larger than motions, larger time measurement units can be employed in measuring them. A camera speed of 2,000 frames per minute was felt to be necessary for the motion breakdown. A speed of 1,000 frames per minute would certainly suffice to measure get and place. There is a strong possibility that ten frames per second would do very well. If these slower speeds were used, the length of film necessary to record a given number of cycles would be reduced to one-half or, in the case of 10 frames per second, one third. This would certainly reduce the analysis time considerably. It not only would mean that there would be less film to crank through the projector, but also the breakpoints would be easier to see. At 1,000 frames per minute the hand moves twice as far from one frame to the next as is the case at 2,000 frames per minute.

Computing the skill measure from the ratio of fast to normal performance takes only one division. Computing the skill measure by correlation requires the many times longer computation of the coefficient of determination. The ratio is computed in less than a minute. The correlation coefficient requires about forty-five minutes when a fully automatic calculating machine is used. The longer time would be warranted if any increase in accuracy resulted, but it does not.

Another point in favor of the get-place breakdown is the consistency of data from one film analyst to another. The breakpoints are so much simpler and easier to recognize that one analyst will get virtually the same result from a given film as another. This is certainly not true in the case of the complete motion breakdown. It is so much easier to get consistent results with the get-place breakdown that it seems feasible to standardize the film analysis methodology. Standardization would provide comparability of data collected by different people and at different times and places. If film analysis were standardized, it seems inevitable that the true relationships of motions would be discovered. Such a degree of comparability would permit the accumulation of findings. Any substantial progress in this field is strictly dependent upon following a procedure which permits the building of research upon the foundation of preceding research. Little can be done if each must start at the very beginning.

Recommendations

It is recommended that standard procedures be adopted for the collection of time data for agricultural marketing operations. Since

the combined motions which comprise get and place can be measured with consistent accuracy and without excessive training in film analysis, it is believed that this level of breakdown should be given very serious consideration as the standard practice. If an alternative is considered, it is believed that complete cycle data would be quite appropriate, because it is even simpler to do and somewhat cheaper.

In so far as the complete motion breakdown is concerned, let that be reserved for motion study in the qualitative sense. Where a large volume of data is to be collected, some work at this level is quite useful in working out accurate descriptions of motion patterns. It need not be used for the main body of data.

In any case, the motion pattern description should be most complete. It should refer to motions and to the significant factors which affect them.

Camera Versus Stop Watch

Experience gained during this project emphasizes the value of using the motion picture camera for collecting time data. The camera is a more accurate time measurement tool, but that is not its greatest value. Even more important is its facilitation of accurate description of the motion pattern. When one is using a stop watch, his attention is partly on the work and partly on the watch. Even if he could ignore the watch, the task of describing the motion pattern would be too difficult. Taking the motion pattern on film provides the most accurate description and also provides a permanent record.

If standardization in the methodology is to succeed, there must be a means for resolving data discrepancies which arise between researchers. If there is a film record, this sort of thing can be easily handled.

The usual argument against the use of the camera is expense. If the get and place or cycle analysis is used, the film cost can be cut in half or to a third. One can use negative film and analyze from negative images. If one processes his own film, the film costs can be reduced to about half by using negative film. This does not allow for labor time but the film processing can be handled as a catch-crop. No extra labor will be needed to do it in most cases. If the slower speeds such as 10 frames per second are adequate, one can reduce film costs even further by using the very inexpensive fine grain positive film. This film has a very slow emulsion speed but is not an inferior product. If anything, it gives an even sharper image. Both the negative and positive emulsions would develop to a negative image. However, analyzing a negative image is not a handicap. About 20,000 feet of negative film was used in this project. There was no noticeable increase in analysis time.

Even with the use of the camera it is expedient to record certain items of description at the time the pictures are made. Weights and distances are much easier measured at the actual work place than later.

Field Data Versus Controlled Conditions

There is such a variety of conditions encountered in collecting data from field operations that the factors affecting performance time are confounded beyond recognition. One must resort to controlled conditions in order to measure the effect of a factor. It is not necessary to use artificial objects, however. The word "laboratory" does not convey an accurate description of what is needed. In industrial training, frequently there is a work place set up, with all equipment, in a separate room away from distraction. This is called "vestibule" training. A similar set-up for collecting data is quite satisfactory. The principal points are to avoid the variety of distractions and changes of working conditions, and to obtain control over the situation. This is virtually impossible on the plant floor. It is extremely important that factors other than the one being measured be kept reasonably constant.

Commodity Table Versus Basic Motion Time Table

The usual form of tables of predetermined time standards is the generalized type which are intended to cover all types of motions in a single table. These tables are not too hard to understand but are most difficult to apply. There are so many work operations which do not seem to fit the generalized descriptions. On the other hand, one frequently faces a dilemma, because the description of two classes of a motion fit about equally well but the performance times are widely different. It is not believed that accurate and consistent results can be obtained by using these generalized tables. Too much is left for interpretation by the user.

If tables are prepared which are limited to certain specific operations, the application can be greatly simplified. Specific objects are named. There can be no doubt what one is talking about when he calls the object by name. If one uses a generalized description, there is considerable opportunity for misunderstanding.

Those who prepare tables have a good notion of their limitations. Others do not. If the user needs a table of time values for packing tomatoes, it is better for that table to be prepared by those who collect the data. Generalizations are certainly possible, but only those who are experienced in handling such data are in a safe position to make them.

It is most emphatically recommended that tables of predetermined time standards for agriculture refer to the specific commodity by name. Other objects related to the handling of this commodity should also be referred to specifically.

Choice of Time Measurement Unit

People who have had the opportunity have, for various reasons, selected the gamut of time measurement units. They have used decimal hours, decimal minutes, decimal seconds, frames, winks, and others. There is no reason to limit the number or variety of these for the collection of data. Whatever is best suited for the measurement should be used. Usually the choice will be made on the basis of what equipment is available to use. However, there should be some consistency in the time units used in presenting material.

The decimal minute is the most popular time unit in industrial usage. That provides a strong argument for its adoption for agricultural use also. However, the decimal minute has disadvantages. In expressing very small intervals of time, one must either use an inconvenient number of decimal places or provide explanations for not using them. Motion data generally runs to the very short time intervals. The other disadvantage is that the decimal minute introduces a new and unfamiliar unit of measure. Even after several years of using it, the members of this project staff do not feel that it conveys the meaning as well as time expressed in seconds. People are accustomed to thinking in terms of seconds and cannot change as rapidly or thoroughly as one might expect. It is as though one were to express yards in decimals. One can understand what is meant, but it destroys the ability to estimate except by translation into a more familiar unit. The question is, "Why translate?" The decimal second is quite adequate and more meaningful. The data below provides an example for comparison.

Minutes	Seconds
.1156	6.94
.5930	35.58
.0746	4.44
.0786	4.72
.1365	8.19
.0366	2.20
.1457	8.74
1.1800	70.81

Application of Standards

It is often assumed that there is one time value and only one which represents normal performance for a given task. This cannot be true. There are many conditions which affect work performance. If the definition of normal must mean normal temperature, normal pay, normal light, normal health, normal personnel relations, normal equipment and the thousand and one other conditions which make up the total job environment, there is perhaps no task existing which fits the description. The "normal" would not be very meaningful.

The only concept of normal which has any tangible meaning is the average one - one of the measures of central tendency. The data used herein was the average of fifteen different people. About 80 percent of these people were experienced in the handling of the particular commodity.

In order to make certain that each person gave a performance which might be classified as normal for him, he was also requested to give a fast performance. The rate at which the operator worked was not controlled, but he was requested to make his normal performance noticeably slower than his fast performance. In order to tie the performance rate down still more, the operator was asked to take a pace for normal which he could do all day without too much fatigue. It is believed that the "normal" rate obtained by the above procedure meets satisfactorily the usual concept of normal.

Although the data included herein are meant to be used chiefly for the appraisal of alternate methods, they might also prove useful in other applications. This statement is made with a word of caution against accepting any time data as normal in any final sense of the word. Predetermined motion time standards provide a good estimating tool. They are accurate only in contemplation of any alternative procedure. In an absolute sense, they cannot be called accurate.

It takes but little thought to realize that any procedure for arriving at a normal performance time other than the collection of data and computation of an average is a guess. It is only wishful thinking to believe that a person can recognize normal performance simply by observation. It is even worse to think that he can estimate accurately the percent above or below normal which a worker is working at.

In using the table data for anything in the nature of estimates covering a whole day's work, one must include the proper estimate for all auxiliary elements. When one is packing, there is a necessary amount of time for setting aside filled crates and obtaining empties. Furthermore, an allowance must be made for personal time, unavoidable delays and rest to overcome fatigue. A table of allowances is given on page 370 of R. M. Barnes' text, "Motion and Time Study."*

Presenting Data for Non-Technical Users

It has been recognized that motion-time tables would receive wide acceptance if they could be simplified to such degree that a lay user could apply them without having to go through a lengthy period of training in their use. If one contemplates a generalized table of

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* Ralph M. Barnes. Motion and Time Study. New York. John Wiley and Sons, Inc. 1949.

basic motions, that is perhaps an impossible goal. However, the use of such a table can be greatly simplified if it is set up for a specific commodity or commodity class and subdivided on the basis of specific operations.

Technically trained individuals can get considerable value from time values for subdivisions of the total cycle. The lay user is probably more often confused than edified by such detail.

When one is thinking of a generalized table, there appears to be no limit to the combinations of motions which could be set up to represent some particular piece of work. However, when one limits the intended use of a table to one commodity or commodity class and to the specific operations which are used in the handling of that commodity or commodity class, there is a reasonably small number of motion patterns which are needed. It becomes practical to present data for whole motion patterns or cycles.

For presenting to lay users, it is recommended that the term "motion pattern" cover all of the distances of reaches and moves as well as all of the variations in weight of the particular commodity or class of commodities.

Taking the commodity class of glass jars, one might set up data as follows:

Motion Pattern A. Grasp one jar per hand. From case. Move to shelf. Position jar on shelf. Release.

	Skill Ratio	Time Per Jar	Time Per Cycle
pint 18"	.64	36	73
pint 24"	.69	39	78
pint 30"	.70	42	84
pint 36"	.70	44	89
quart 18"	.67	39	78
quart 24"	.68	43	86
quart 30"	.68	46	92
quart 36"	.67	49	98

All of this data would be referred to as Motion Pattern A. Motion Pattern B might refer to the pattern in which orienting is required. More lengthy descriptions of each motion pattern might be desirable but the form of the above data is much simpler than data for subdivided cycles.

SUMMARY

Improvements of work methods in agriculture resolves itself into the problem of finding a technique which will permit an individual to objectively select the most effective work method from among several alternatives. Comparison of commonly used techniques such as pure judgment, orthodox time study, and predetermined time values reveals that they basically differ in the amount of judgment involved. The pure judgment technique is self-explanatory. Orthodox time study incurs a large element of personal judgment during the process of rating the worker's rate of activity or "leveling" for worker effort. The individual doing the rating has no absolute check on his accuracy. Tables of predetermined time values or average times require judgment when they are applied. When the tables are presented with sufficient descriptions and definitions, the judgment factor is reduced to a minimum.

In earlier research it was concluded that predetermined time values offer the best known technique for the selection of improved work methods in agriculture. It was concluded that data for the predetermined motion time values could best be obtained by means of the controlled experiment or laboratory method. Operators are employed to perform in the laboratory the same handling operations on the actual commodity in which they are experienced. The fact that they are working in a laboratory instead of a field operation permits the control of many vital conditions which, when encountered in field operations, seriously limit the extent and value of time data. In field operations it is impossible to hold constant, or for that matter, measure such variables as general layout, distances and quality standards. Interruptions in field work are frequent, making the collection of normal performance data extremely difficult. Machine timed operations are common in the field and data obtained under these circumstances loses meaning in so far as a table of time data is concerned. The irregularity of field operations and the continual shifting of motion patterns by the workers forces an expensive oversampling of one motion class in relation to others. The film editing and analysis also is complicated to a serious degree. Among field operations it is not possible to maintain constant working conditions such as light, ventilation, noise, fatigue, temperature and comfort facilities.

In the final analysis it is apparent that if data can be taken from one group of field operations with all their wide differences and applied to one specific operation, then data from a realistic laboratory can be applied also. The controlled laboratory method economically permits the wider and more complete study of a greater number of marketing operations, provides more accurate data and makes feasible the evaluation of motions in terms of skill and effort.

A field survey of the operations most commonly performed in a variety of marketing processes was recorded on 16 mm. film at the

beginning of this project. This provided a wide range of motions from which the most commonly used in the handling of the various commodity groups were catalogued. Many motion patterns found in the variety of marketing operations were eliminated on the basis of their inability to be classified as marketing, lack of economic importance or standardization of quality. Thorough study of the survey films made it possible to catalogue the motions with the detailed description and accurate classification essential to successful motion analysis. From this catalogue of motions, those for intensive study were selected and combined by commodity groups in all the desirable motion patterns for testing.

The actual testing required three phases within each commodity group. The first phase was a preliminary trial run of the group of motion patterns by two operators and sample pictures were taken. This provided an opportunity to make necessary modifications in the test equipment, improve the photographic techniques and eliminate or add motion patterns on the basis of observation. The second phase was a full testing of the selected motion patterns by a minimum of eight operators. These films were analyzed and a completed statistical analysis was made of the data obtained. This data for a rather complete set of motion patterns made it possible to determine which motion patterns should be eliminated or added to provide a satisfactory table of predetermined motion times for that commodity group. The third phase then was the testing of this group of motion patterns by at least seven more operators. The original eight operators were brought back for testing on the motion patterns which had been added in this final group. This provided a sample of at least fifteen operators for each of the motion patterns to be utilized in the tables. Since each motion pattern was performed at two levels of effort, normal and high, the ten or more cycles for each level of effort resulted in a minimum of twenty observations per motion pattern for each operator.

Upon completion of the film analysis of the first commodity group, sufficient data was available to statistically determine which measure of central tendency would be used throughout all tables. The mean, median and mode computations clearly indicated that the arithmetic mean more nearly met the requirements. The deciding factor was the erratic nature of the median and modal values. For example, in several instances they indicated inverse time-distance relationships. Such illogical results ruled out the possibility of using the median or mode.

The distribution of the data as well as the central tendency was calculated. Thus the final tables show for each subclass of motion not only the mean value but also the dispersion. For clarity of meaning, the dispersion is shown as a percentage rating with the average normal performance time for all fifteen operators equal to one hundred.

In the process of obtaining the project data, it was found that orthodox photographic techniques were extremely costly and/or inadequate in some phases of this type of research. An extensive diary of notes was maintained and incorporated in a detailed explanation of improved photographic techniques.

Completion of the film analysis and statistical work on all of the motions made possible full comparisons across commodity lines. Three important problems became apparent and their answers significantly affected the value of the results of this project. These problems were the method of presenting the motions in table form relative to description and classification, the inaccuracies of the motion times because of the arbitrary breakpoints of the motions and the obvious variability of the skill evaluations or correlations which was also caused mainly by the arbitrary breakpoints of the motions.

Presenting the tables of motions in the commonly used generalized description form introduced serious limitations in the applicability of the data. On the basis that the best way to describe an egg is to call it an egg, the data is applied to the actual commodity from which it is derived and presented by commodity groups. These tables are in inventory form and by motion pattern according to work operation, thus simplifying the application of the data. Variable factors within each of the commodity groups are analyzed separately on the basis of skill and method.

The second problem, inaccuracies in the motion time data because of the arbitrary breakpoints, was solved by the simple expedient of combining the motions reach and grasp into an element called get while the motions move and position-release became place. The fact that the get and place breakpoints are easily defined is reflected in the high consistency of the findings. The overlapping of the factors influencing the respective motions within get and place is eliminated. The get and place data is handled in a manner similar to the motion data with the exception of the measurement of skill. The correlation measure of skill is not used and an effort ratio provides the measurement of skill.

This new skill measurement was a solution to the third problem mentioned above. Most of the variability of the correlation measure of skill was obviously a result of the inherent inaccuracies in the breakpoints of the motions. This basic weakness is avoided by the use of get and place data in the new technique of skill measurement. This new technique is a ratio of the high effort to the normal effort. It provides skill evaluations of a high consistency.

The reliability of the get and place data made feasible the development of a set of simplified tables. These tables provide the least complicated means of selecting better methods. They emphasize the influence which the various factors have on the individual motions since the overlapping of the factors is eliminated. The true nature of many of the "principles of motion economy" are well illustrated.

The final step was the testing of the table data. Successful application tests were made in apple packing and the stocking of grocery shelves. The tables accurately predicted the relative times which the operators required in performing the motion patterns even though the absolute time values differ somewhat as would be expected. There were no deviations in the predictions of the table for the application tests because the tables are designed to show the relative rather than the absolute values of the motions.

To enhance the value of the tables by broadening their application, a large number of commodities not included in the tables were classified in terms of the tables. Using their handling characteristics as a basis for making estimates, the performance time for these products is expressed in terms of the table data. Some preliminary test data not included in the tables served as a base and proved helpful in making these estimates.

During the progress of the work there was ample opportunity to observe and overcome some of the many difficulties associated with methods instruction. These experiences coupled with information obtained from consultations with specialists provided valuable material which is offered in the section on instruction methods.

A general critique was made of each of the problem areas found in methods engineering. Specific cases within each of these areas were cited. Recommendations were also made concerning the collection of time data, the commodity table versus the basic motion time table, the choice of time measurement unit and the application of standards.

The researcher in the field of work methods improvement may utilize at least three different approaches. One of these is the selection of a better method from several already in use. Another common approach is to synthesize a new method from the better parts of existing methods. Innovation is also a valuable tool in methods improvement. The value of these approaches is directly related to the accuracy and flexibility of the technique of methods appraisal and selection employed. Tables of time values alone provide the required accuracy and flexibility. They offer an objective measurement of existing methods in terms of time and skill requirements. Since the table data are presented in basic work units, it is possible to synthesize these units and predict the relative performance time of an entirely new method. However, innovation is greatly aided by tables of time data because the researcher has access to accurate measurement of the effect of important factors on performance time. In effect the "principles of motion economy" are given weight and value. Thus the tables of time values provide a flexible tool for the objective appraisal and selection of improved work methods in agriculture.